Annals
of the
Missouri Botanical Garden

Vol. 26 NOVEMBER, 1939 No. 4

NEW OR OTHERWISE NOTEWORTHY APOCYNACEAE OF TROPICAL AMERICA. VII[1]

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Mortoniella Woodson, gen. nov. Apocynacearum (Plumerioideae-Alstoniinae). Calyx 5-partitus eglandulosus; laciniae scariaceae vel paullulo foliaceae imbricatae sat aequales mox caeduces. Corolla salverformis; tubus gracilis basi paulo gibbosus ibique staminigerus; limbi laciniae 5 paulo inaequales aestivatione sinistrorsum convolutae. Stamina 5 epipetala profunde inclusa; antherae inter se liberae 4-loculares omnino fertiles nullomodo appendiculatae; filamenta perbrevia. Ovarii carpella gemina basi distincta apice in stylo aequilongo turbinato producta, ovulis 12, 4-seriatim superpositis; stigma breviter fusiformi-capitatum. Nectaria nulla.—Arbores vel frutices (?). Folia alternata petiolo medio glandulo-umbonato caeterumque eglandulosa integra penninervia. Inflorescentia terminalis thyrsiformis.

Mortoniella Pittieri Woodson, spec. nov.; arborea vel fruticosa (?); foliis alternatis longe petiolatis oblongo-ellipticis apice longiuscule subcaudato-acuminatis basi acute obtuseque cuneatis 10–13 cm. longis 2.0–3.2 cm. latis membranaceis omnino glabris dense subhorizontaliterque nervosis, petiolo ca. 2.5 cm. longo medio glandulo-umbonato; inflorescentiis thyr-

[1] Issued November 30, 1939.

soideis terminalibus plurifloris 2.5–6.0 cm. longis; pedicellis 0.5–0.7 cm. longis; calycis lobis late ovatis vel ovato-oblongis obtusis 0.15 cm. longis extus minute puberulis; corollae salverformis tubo 1.5–2.0 cm. longo basi ca. 0.12 cm. diam. deinde paululo gibboso-inflato fauces versus gradatim ampliato extus glabro intus basi villoso-barbato caeterumque glabro, lobis oblique obovato-oblongis rotundatis paulo inaequilateralibus 1.7–2.0 cm. longis 0.5–0.7 cm. latis patulis; antheris compresse ellipsoideis 0.15 cm. longis; ovariis compresse ovoideis ca. 0.1 cm. longis glabris; stigmate 0.1 cm. longo; fructu ignoto.—Costa Rica: bois de la baie de Salinas, July, 1890, *H. Pittier 2912* (Herb. Inst. Bot. Lausanne, type).

It is most unfortunate that both the habit and the fruit of this remarkable plant are unknown. I suspect that it is rather closely related to *Aspidosperma,* but it is without a gynoecial nectary, and both the caducous calyx-lobes and the peculiar petiolar glands are quite unlike anything in the Apocynaceae known to me. The aspect of the specimen somewhat resembles *Vallesia,* but the number and arrangement of the ovules are quite different, of course, and the characteristic intrapetiolar glands of the latter genus are lacking. The genus is named in honor of Mr. C. V. Morton, of the United States National Herbarium, who called to my attention the type specimen, which had long remained unidentified in the Institut de Botanique of the University of Lausanne.

Prestonia **dentigera** Woodson, sp. nov. Frutex volubilis omnino glabrus altitudine ignotus, ramulis gracillimis internodiis ca. 15–18 cm. longis; foliis obovatis vel obovato-oblongis apice rotundatis et abruptissime breviterque apiculatis basi late obtusis 15–17 cm. longis 7.5–9.0 cm. latis membranaceis, petiolo 1.0–1.5 cm. longo; inflorescentiis lateralibus, pedunculo sterili 5 cm. longo, ramis florigeris 3 cm. longis, bracteis setaceis vix 0.1 cm. longis, pedicellis geminis 1 cm. longis; calycis lobis oblongo-lanceolatis acuminatis foliaceis plus minusve purpurissatis 0.5–0.6 cm. longis, squamellis late dentiformibus apice minutissime erosis; corollae ut dicitur flavidulae saturateque rubrae tubo 1.5 cm. longo basi ca. 0.25 cm. diam., lobis

late dolabriformibus minute apiculatis 0.8 cm. longis patentibus; appendicibus epistaminalibus oblongis vix inclusis; antheris oblongo-sagittatis 0.6 cm. longis dorso minutissime puberulis apice paulo exsertis; ovariis ovoideis ca. 0.15 cm. longis glabris; stigmate subcapitato-fusiforme 0.15 cm. longo; nectariis carnosis conspicue dentiformibus compresse ovoideis basi vix concrescentibus apice distincte acuteque lobatis basi vix concrescentibus; folliculis ignotis.—COSTA RICA: vicinity of El General, Prov. San José, alt. 640 m., Jan., 1939, *A. F. Skutch 3864* (U. S. National Herb., TYPE).

This species is closely related to *P. concolor* (Blake) Woods. and *P. obovata* Standl., but differs from both in the trichotomous inflorescence and the very peculiar, tooth-shaped nectaries.

MESECHITES TRIFIDA (Jacq.) Muell.-Arg. var. **tomentulosa** Woodson, var. nov., a varietate typica planta tota corolla excepta dense minuteque tomentulosa differt.—BRAZIL: Taperinha bei Santarem, im Bestand der *Montrichardia arborescens* kletternd, July 10, 1927, *A. Ginzberger 351* (Herb. Field Mus., TYPE). Recalling *M. bicorniculata* (Rusby) Woods., but with the floral dimensions of typical *M. trifida.*

TWO NEW ASCLEPIADS FROM THE WESTERN UNITED STATES[1]

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During the preparation of a revision of the North American species of *Asclepias,* two novelties from the western United States have been encountered which it seems well to record, since the date of publication of the complete work is uncertain.

Asclepias **Davisii** Woodson, spec. nov. (fig. 1). Herbae perennes parvulae subsucculentae prostratae; caules basi fasciculati 1.0–1.5 dm. longi plus minusve compressi simplices glabri; folia opposita late ovata vel ovato-elliptica apice obtusa vel abrupte breviterque acuminata basi late obtusa aut rotundata aut late obscureque cordata non rarius plus minusve decurrentia cum petiolo ca. 0.2–0.4 cm. longo 3.0–4.5 cm. longa 1.5–4.0 cm. lata inferne multo minora dilute viridia plus minusve glaucescentia glabra; inflorescentia terminalis umbelliformis 5–15-flora sessilis, foliis minoribus 1–2 subtendentibus, pedicellis 2 cm. longis glabris; calycis lobi elliptico-lanceolati acuminati 0.6 cm. longi sparse pilosuli; corollae rotatae dilute luteo-viridis lobi patuli ovato-elliptici late acuti 1.0–1.2 cm. longi 0.6–0.7 cm. lati intus papillati vel minute pilosuli extus apicem versus plus minusve purpurissati; staminum columna carnosa ca. 0.3 cm. alta, antherae 0.25 cm. longae dilute viridulae apicibus scariaceis obtusis inflexis, alis aequilateralibus late obtusis integris, coronae foliolae calceolatae carnosae livide purpurissatae 0.5 cm. longae 0.35 cm. latae compressae prope margines interiores ca. 0.1 cm. longae abrupte apiculatae basi columnam totam adnatae, corniculo incurvato adnato omnino incluso vel nullo; pollinia ca. 1.5 mm. longa compressa anguste inaequilateraliterque pyriformia, caudiculis gracilibus tortulis ca. 0.5 mm. longis, corpusculo compresse rhomboideo ca. 0.25 mm. longo; folliculi non visi.

[1] Issued November 30, 1939.

IDAHO: Glenn's Ferry, Elmore County, May 15, 1938, *R. J. Davis 85* (Herb. Missouri Bot. Garden, TYPE); OREGON: loose soil, high hillsides opposite Lloyd Humphrey's ranch, Grant County, April 30, 1925, *L. F. Henderson s.n.* (Herb. Missouri Bot. Garden).

Professor Davis writes me: "The plant grows prostrate on the ground with nothing but the ends of the branches turned slightly upward. The stem is a pale green color, but I did not

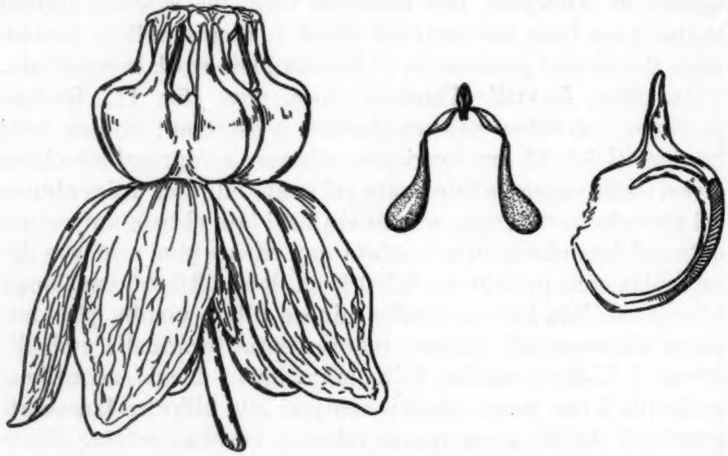

Fig. 1. *Asclepias Davisii* Woodson. Flower, pollinia, and hood in longitudinal section. (Drawn by A. A. Heinze.)

look particularly to see whether it was flattened or not. . . . It seems to grow only on barren alkaline clay knolls. There was no plant of it found growing where any other vegetation grew."

A. Davisii closely simulates *A. Cryptoceros* Wats. in general appearance and distribution and is doubtless closely related to it. In the former, however, the corona hoods are more abruptly apiculate and scarcely attain the anther-head which they considerably surpass in the latter, where the flowers are somewhat larger as well.

The two specimens cited, although essentially similar, show certain dissimilarities of the corona: the hoods of *Davis 85* are more abruptly and shortly apiculate and are without the

inconspicuous, incurved horn characteristic of *Henderson s.n.* The character of the horn appears to be unusually inconstant in certain species of the western United States, notably in *A. californica* where I have observed a series of intergradations from a very definite structure to complete obsolescence. Similar variation is shown strikingly in the following species as well.

Asclepias **Cutleri** Woodson, spec. nov. (fig. 2). Herbae perennes parvulae; caules basi fasciculati suberecti 1–2 dm.

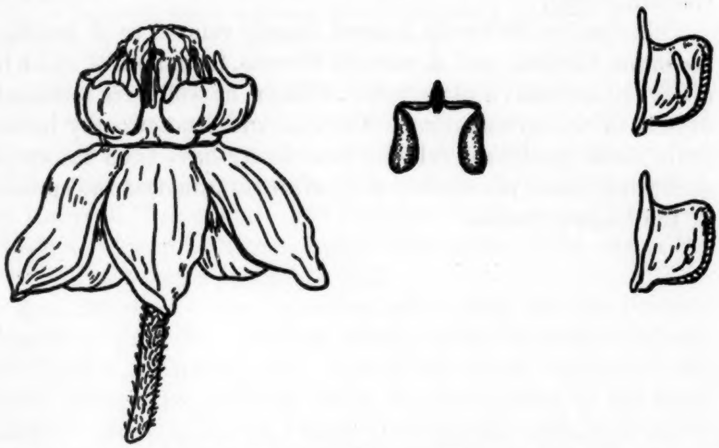

Fig. 2. *Asclepias Cutleri* Woodson. Flower, pollinia, and two hoods in longitudinal section to show variation of the horn. (Drawn by A. A. Heinze.)

alti tenues simplices vel rarius pauciramosi minute pilosuli; folia opposita vel approximata subsessilia linearia apice acuminata basi attenuata cum petiolo vix bene manifesto 4–8 cm. longa ut videntur subsucculenta minute pilosula dilute viridia; inflorescentia in axillis foliorum lateralis pauciflora brevissime pedunculata vel verisimiliter sessilis, pedicellis ca. 1 cm. longis minute pilosulis; calycis lobi ovato-lanceolati acuminati dense pilosuli; corollae rotatae dilute lividae lobi patuli ovato-elliptici late acuti 0.5–0.6 cm. longi ca. 0.2 cm. lati extus minute sparseque pilosuli intus minutissime papillati; staminum columna carnosa ca. 0.1 cm. alta inter foliolas coronae saccata, antherae 0.15 cm. longae apicibus scariaceis obtusis inflexis,

alis obtusis integris; pollinia compresse subrhomboideo-pyriformia ca. 0.75 mm. longa, caudiculis corpusculoque ca. 0.25 mm. longis, coronae foliolae saccatae carnosae 0.15 cm. longae dorso obtusae, lobulis lateralibus acutis prominentibus, corniculo parvo vel subnullo incluso; folliculi penduli ovato-fusiformes ca. 5 cm. longi dense pilosuli.

Arizona: rare on sands, 5 mi. west of Rock Point, Apache County, June 15, 1938, *H. C. Cutler 2177* (Herb. Missouri Bot. Garden, type).

This species obviously is most closely related to *A. brachystephana* Engelm. and *A. uncialis* Greene, from both of which it differs in its habit and narrower foliage, as well as in technical details of the gynostegium. Perhaps most noteworthy is the fruit, since pendulous follicles previously have been known to occur only in *A. perennis* and *A. albicans* amongst the species of the United States.

CONTRIBUTIONS TOWARD A FLORA OF PANAMA[1]

III. Collections during the Summer of 1938, chiefly by R. E. Woodson, Jr., P. H. Allen, and R. J. Seibert

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During the summer of 1938, from June 17 to August 20, a party consisting of R. E. Woodson, Jr., Paul H. Allen, and Russell J. Seibert was sent to Panama under the joint auspices of the Missouri Botanical Garden and the Arnold Arboretum of Harvard University. The purpose of the expedition was chiefly to recoup the losses sustained in a fire at the end of the previous summer's collecting trip.

As in previous years, numerous short trips into the interior were made from the Tropical Station of the Missouri Botanical Garden at Balboa, C.Z., now under direct control of the Canal Zone. The principal trips, however, were to the highlands on Chiriquí on the Pacific slope of the Volcán de Chiriquí, a favorite collecting locality since the days of Seemann and Warscewicz, and the lowlands about the Chiriquí Lagoon in Bocas del Toro, upon the Atlantic slope. A projected trip to Darién was necessarily postponed because of the illness of both Woodson and Seibert. This trip was taken later in the year by Allen, and will be reported in the next of this series.

Although it is still possible to make the trip to Chiriquí rather painfully by cattle boat, use of the airplane and the new Panamerican Highway has decided advantages. Regular flying service from Panama City to David, the capitol city of Chiriquí province, reduces the time between the two cities, from a day and a night via the lowing and odorous hulls of the Compañía de Navegaciónes Chitreana, to a mere two hours.

[1] Issued November 30, 1929.

Air travel, however convenient, has its drawbacks for the botanist. Many miles of vegetation-covered wilderness is given an exasperatingly distant enchantment. And should he be a timid soul, the wilderness becomes forbidding indeed if a precipitant descent is contemplated. In 1935 Woodson and Seibert, together with Dr. George W. Martin, had a taste of such interest when the landing gear of their plane was wrecked at the very moment of take-off, on an improvised landing field at Llanos del Volcán, in Chiriquí. Safe landing at that time was made by the skill of Robert Marstrand, the pilot, who was killed on the same route later in the summer, flying headlong into the clouded summit of Cerro Trinidad.

Taking all such things into consideration, a light truck was purchased by Allen and converted into a cavernous conveyance for enough collecting and pressing materials for a month. On top of all the other paraphernalia a precarious garnish was made of a number of living ornamental plants potted in tin cans and intended for our good friend Mr. T. B. Mönniche at Boquete. The whole cargo, heaped high, was covered with water-proofed canvas, and we set upon our way.

The Panamanian section of the Panamerican Highway is known locally as the *Carretera Nacional*. The preceding summer we had made the approximately 300-mile trip from Panama City to David in an ancient, specially chartered *chiva* (a light bus, but in Spanish, appropriately, a goat). We found then that most of the western half of the road was either in the process of being blasted from solid rock or cut through jungle, and the whole trip required twenty-eight hours of continuous driving. When all other details of that trip vanish, the scientific occupants of the *chiva* will probably still remember how, during each of those twenty-eight hours, they took turns holding up the windshield with their feet for the expressed benefit of the Panameño driver, bounding over the *Carretera* in a most unnatural position.

This year, however, we not only rode in a ¾-ton truck provided with springs, but found to our delight that the road had been improved quite noticeably, enabling us to reach David

after only fourteen hours. Although the road had been much worked upon during the year's interval, the surrounding country was still unspoiled, and we were able to make numerous collections en route, including several novelties. Even from the road, for example, the bright orange flowers of *Tussacia Woodsonii* Morton, abounding in the low woods near Remedios, could be distinguished from the rather greenish yellow flowers of the common *T. Friedrichsthaliana.* So with a grinding of brakes and a tornado of dust, a new species was added to the interesting family Gesneriaceae. In the swampy jungles near the Río Fonseca the attention of any motoring botanist could scarcely miss the giant, scarlet-bracted canes of *Costus Lima* K.Sch., previously unknown from Panama. Not a hundred yards from the road we ate our lunch under a tree in which were twining *Fernaldia speciosissima* and *Prestonia remediorum,* new species of Apocynaceous lianas.

Nightfall found us established at the cavernous Pension Italiana in David. Early the next morning we abandoned the truck and transferred our gear to the narrow-gage train for the trip to Boquete. The line is only about thirty miles long, but is at such a continuous grade from David, about 50 m. elevation, to Boquete, about 1000 m., that it appeared to be all the diminutive locomotive could possibly do to pull us thence in three hours.

The name Boquete is well deserved, for it means "The Bouquet." The town, of perhaps 1,000 inhabitants, is set at about the elevation of Cartago, in Costa Rica, and is favored with a climate that is almost ideal. With the Volcán de Chiriquí towering above, it lies in a deeply forested canyon of the tempestuous little Río Caldera. Nearly everyone in town has a luxuriant garden almost monotonously filled with blooming roses, lilies and delicious strawberries. Not far up the mountain slopes a native raspberry *(Rubus glaucus* Benth.) abounds, which is really superior to the best cultivated berries of the States. It is no wonder that Boquete is a favorite alike for vacationists from the Canal Zone and for nearly all botanists who visit Panama.

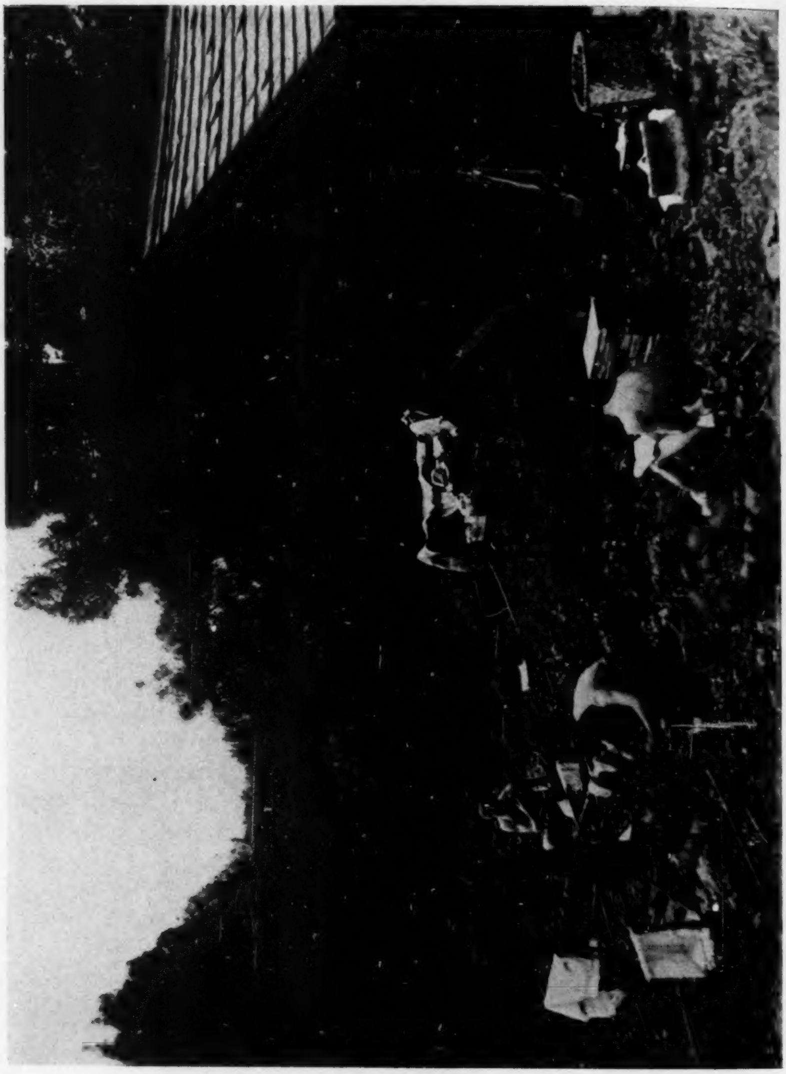
But the real attraction of Boquete is that it is not far from Finca Lérida, the remarkable establishment of Mr. T. B. Mönniche, nearly 300 m. higher upon the slope of the volcano. It is doubtful whether Mr. Mönniche and his charming wife themselves know how many pilgrims to Finca Lérida they welcome each year. Surely in Panama, if not in all Central America, there is not another finca where the coffee is more successfully grown and handled, where the native help is more kindly and wisely administered, and where the proprietors are more gracious to all with whom they come in contact.

Mr. Mönniche is a keen naturalist himself, and fully understood our needs in studying the local vegetation. Accordingly, as in the previous summer, he placed at our disposal a little maintenance shed, "Casita Alta," about three miles farther up the slope of the volcano, at an elevation of about 2,000 m. Casita Alta furnishes the greatest requirement of a visiting plant collector, particularly in the rainy season: it is dry. Otherwise, it is a frame structure of about ten by eight feet, without windows, floor or furniture except a shelf in the back for our supplies. A bed is made by pulling fronds of the abundant *Pteris podophylla* Sw. *(sensu lato)*, and making a mat on the dusty floor for sleeping-bags. Fire-making and cooking, as well as the drying of specimens, must be done out of doors.

We found Casita Alta exactly as we had left it at the end of the preceding summer, even to the sprig of mistletoe hung over the door like the sword of Damocles. Immediately after unpacking our belongings that Mr. Mönniche thoughtfully had had packed up the mountain side for us by mule-train we set about the construction of a "pressing room," or rather, a canvas shelter for our press-frames. During the rainy season, at least, artificial heat is necessary for drying in the tropics. After experiments over several collecting seasons, we have found that the one-unit, pressure kerosene stoves of Swedish make are by far the hottest, safest, and most economical.

It would be difficult to find a site more attractive to the botanical collector than that of Casita Alta, since it is located within easy reach not only of the deep valley of the Río Caldera

AN ALPINE MEADOW NEAR THE SUMMIT OF VOLCAN DE CHIRIQUI



THE CAMP AT CASITA ALTA, SUMMER OF 1937

headwaters, but of the higher slopes of the volcano itself. We soon found that it was a good arrangement for two of the party to go fairly far afield, leaving the third to tend the kerosene stoves. Incidentally, the one left could collect in the immediate vicinity of the camp, where much of interest was to be found, including the gigantic *Piper Gigas* Trelease, a tree 10 m. tall with a bole 30 cm. in diameter. Another very distinct pepper of similar height but more slender bole is *P. affectans* Trelease, also in this immediate vicinity. A rather rare borage, *Hackelia costaricensis* (Brand) Johnston, was so common in the immediate clearing around camp that it appeared to be an introduced weed.

After about three weeks of collecting from Casita Alta, including a trip to the summit of the volcano, we packed up our sundries, and descended to Boquete, paying our respects, en route, to the Mönniches, through whose kindness we had had such a delightful and profitable visit. The region about Boquete, aside from the Canal Zone, is probably the best known botanically of Panama. Nevertheless, things were made so convenient for us at "El Hotel Nuevo" that we could not forego a few days of foray, which resulted in the discovery of several interesting species.

Back in the Canal Zone again, several trips were made toward Chepo, to the east, and Arraiján, just over the boundary to the west. A visit of several days was made to the island of Taboga, in Panama Bay. Although the island has been a favorite resort from the mainland since the days of Spanish domination, and has been visited probably by every botanist to collect on the isthmus, a number of additions were made to the flora of Panama, including the antillean *Forsteronia spicata* (Jacq.) Meyer, which grows in veritable thickets along the northern shore.

The last two weeks of collecting were spent by Woodson in the neighborhood of Almirante, Bocas del Toro province, for a foray at the kind invitation of Dr. Wilson Popenoe and the United Fruit Company. The Atlantic slope of Panama is more poorly known botanically than the Pacific, and this port had

been selected because bi-monthly sailings are made to it from Cristobal by the ships of the Fruit Company.

The trip to Almirante was made with some misgivings, since the place has a rather evil reputation in the Canal Zone as a disease-infested shambles of abandonment caused by the plague of the Panama Disease of bananas. It is quite true that the disease has almost completely wiped out the traffic in bananas at Almirante, but the growing and processing of cocoa and abacá is progressing under very efficient management, and will doubtless restore the importance of the port.

Almirante itself is far from a shambles. The town is neatly maintained, and the people, all employees of the Fruit Company and their families, are the most uniformly co-operative one could wish. It is to Mr. John S. Kelley, the manager of the Almirante Division, and his wife, that we chiefly owe the success and pleasure of our collecting in the neighborhood of Almirante, for it was in their home that we made our headquarters. It is largely due to their hospitality that the impedimenta of pressing supplies were conveniently stored away for use, a safe shelter for the presses and kerosene stoves provided, and arrangements made for trips into the surrounding country. From the manner that every need or wish was anticipated, the visiting botanist would seem constantly to have been rubbing the magic lamp of Aladdin.

At the various Fruit Company plantations, appropriately yet unexpectedly, trained and discerning naturalists were much in evidence. Dr. Cordes and Mr. Arnold both are enthusiastic amateur botanists, and both have fine collections of living orchids. At Nievecito, in the valley of the Río Sixaola, we were most fortunate to have Mr. H. J. Bartlet not only as host, but as a guide and companion in the field. Merely following Mr. Bartlet upon his daily travels about the plantation was reward enough for a visit to Panama, because of his activity, understanding, and knowledge of the native vegetation. It was almost in Mr. Bartlet's "front yard" that a very unusual cucurbit was found which it has not been possible to refer satisfactorily to a genus. A most stimulating visit was made

to Mr. J. H. Permar, near Guabito, in the valley of Río Changuinola. We had long been anxious to meet Mr. Permar, since Dr. Popenoe had commented to me, at several times, on his understanding of tropical natural history. Upon his plantation of abacá Mr. Permar has established a small botanical garden of economic plants suitable for cultivation in the tropics of both hemispheres.

Perhaps the most interesting of the trips taken out from Almirante was that arranged for us by Mr. Kelley to the Río Cricamola at the east end of the Chiriquí Lagoon. Leaving Almirante one morning at about four o'clock, we stopped at the town of Bocas del Toro to pick up Mr. H. Wedel, a local ornithologist and accomplished photographer, who was to act as guide and interpreter. Proceeding thence by the United Fruit Company's Diesel-powered yacht "Talamanca," we arrived at the bar of the Río Cricamola shortly before noon. From the bar, we ascended the river in two long *cayucas,* or dug-out canoes, piled high with every convenience which the Fruit Company could provide, including the precaution of six cages of carrier pigeons for communication to Almirante.

We made our headquarters for the several days of our visit, at a ruined plantation called "Finca St. Louis," not far downstream from the Indian village known as Konkintoë. Once an elaborate establishment, the ill-starred Finca St. Louis is a rambling frame building of two stories in a most dismal state of decay. Nothing now remains of the plantings, the lowland jungle pressing close upon every side, as only such tropical second growth can. Upon the rotting fence-posts was found good collecting of many epiphytes ordinarily growing high in trees. Amongst these were some interesting novelties and new records in Orchidaceae and Gesneriaceae. In the half-submerged borders of the river a good representation of Marantaceae, Zingiberaceae, and Araceae was collected. And with the aid of Martin Sparks, a young Bocatoreño who had accompanied us in a duplex rôle of butler and scientific technician, a fair sample was taken of all available flowering and fruiting trees.

After returning again to the comparative luxury of Bocas del Toro, we accepted the hospitality of Mr. Wedel for a collecting trip upon Isla de Colón, where the town of Bocas del Toro is situated. With only a short time at our disposal, scarcely a decent start could be made in the botanical exploration of this interesting and accessible district. But, thanks to the kindly experience of Mr. Wedel, in only a few days numerous additions were made to the known flora of Panama, here very similar to that of Atlantic coastal Costa Rica. There is probably no one in the vicinity of the Chiriquí Lagoon who is quite so familiar with the country and its inhabitants as Mr. Wedel. Since last spring, he has started independently collecting, sending his specimens to the Missouri Botanical Garden for identification and distribution.

LYCOPODIACEAE

(William R. Maxon, Washington, D. C.)

LYCOPODIUM ERYTHRAEUM Spring—CHIRIQUÍ: Loma Larga to summit, Volcán de Chiriquí, alt. ca. 3000 m., July 5, 1938, *Woodson, Allen & Seibert 1079.* Previously known only from Ecuador, Peru, and Bolivia. It almost certainly occurs in Colombia as well.

ISOETACEAE

(W. R. Maxon and C. V. Morton, Washington)

ISOETES **panamensis** Maxon & Morton, sp. nov. Sect. *Tuberculatae.* Planta aquatica; rhizoma trilobatum grossum, ca. 3 cm. latum; folia rigida, ca. 50, ca. 32 cm. longa, 2 mm. medio lata, apice acuminata, basi valde dilatata (margine hyalina ca. 8 cm. longa, basi 5–6 mm. lata utroque latere), valde triquetra, septis transversis numerosis perspicuis, stomatibus numerosis, fasciculis fibrovascularibus periphericis validis 6; ligula deltoidea, ca. 3.5 mm. longa, 5 mm. basi lata, acuta; vellum nullum; sporangia magna, ambitu elliptica, ca. 13 mm. longa, 6–7 mm. lata; macrosporae albae, 350–500 μ diam., valide ubique tuberculatae, tuberculis non confluentibus, magnis, elongatis (saepe 25 μ longis), apice rotundatis, costis commissuralibus perspicuis; microsporae parvae, ca. 25 μ diam., laeves.—PANAMÁ: pond, vicinity of Bejuco, Aug. 7, 1938,

Woodson, Allen & Seibert 1685 (U. S. Nat. Herb. no. 1,748,502, TYPE).

In Dr. Pfeiffer's monograph the present species seems to be nearest *Isoetes Malinverniana* Cesati & De Not. of Italy. Specimens collected by Cesati and Malinverni and others, kindly lent by the New York Botanical Garden and the Gray Herbarium, show that species to differ in having the ligule lanceolate, the macrospores larger (660–900 μ), and the microspores roughened. *Isoetes cubana* Engelm., of Cuba and British Honduras (?), is a laxer and more slender plant, with macrospores bearing low rounded tubercles. *I. Gardneriana* A. Br. of Brazil is similar in habit, but the macrospores are dark brown and bear fine tubercles.

In the treatment by U. Weber[1] *I. panamensis* would fall in the section *Amphibiae* near *I. Gardneriana* and *I. triangula* Weber. The latter is represented in the U. S. National Herbarium by a specimen of the type collection (*Ule 8000*, from Río Branco, Amazonas, Brazil). It is distinguished from *I. panamensis* by the bilobed rhizome and the small sporangia (5 mm. long).

No species of *Isoetes* has previously been known from Panama, and only one species has been found in adjacent Central America, namely, *I. Storkii* T. C. Palmer, of the mountains of Costa Rica. *Isoetes panamensis* is a lowland species growing near sea level.

HYMENOPHYLLACEAE

(William R. Maxon, Washington, D. C.)

TRICHOMANES ANKERSII Hook. & Grev.—BOCAS DEL TORO: fronds thickly "plastered" to tree trunk, Isla de Colón, alt. ca. 25–75 m., Aug. 18, 1938, *Woodson, Allen & Seibert 1933*. Previously known from Costa Rica, and from Colombia to Bolivia.

POLYPODIACEAE

(William R. Maxon, Washington, D. C.)

DIPLAZIUM LINDBERGII (Mett.) Christ.—BOCAS DEL TORO: vicinity of Nievecito, alt. ca. 15 m., Aug. 8, 1938, *Woodson, Allen*

[1] U. Weber, "Zur Anatomie und Systematik der Gattung Isoetes L.," Hedwigia 63: 219–262. 1922.

& Seibert 1801. This species, newly recorded from Panama, was described from Brazil, and is reported from Mexico (perhaps in error), Colombia, and Venezuela. At the U.S. National Herbarium we have under this cover specimens ranging from Costa Rica to Colombia and Bolivia. The Panama plant agrees with the Costa Rican specimens, but this material may not be conspecific with the Brazilian type. As regarded at present it must be reckoned a polymorphic species.

ELAPHOGLOSSUM DOMBEYANUM (Fée) Moore—CHIRIQUÍ: steep cliffs of Potrero, near summit, Volcán de Chiriquí, alt. ca. 3300 m., July 5, 1938, *Woodson, Allen & Seibert 1048.* Known previously from Colombia, Venezuela, and Ecuador.

STRUTHIOPTERIS LOXENSIS (HBK.) Maxon—CHIRIQUÍ: Loma Larga to summit, Volcán de Chiriquí, alt. ca. 3000 m., July 5, 1938, *Woodson, Allen & Seibert 1067.* Specimens in the U.S. National Herb. are from Colombia, Ecuador, Peru, and Bolivia.

OPHIOGLOSSACEAE

(R. T. Clausen, Ithaca, N. Y.)

OPHIOGLOSSUM NUDICAULE L.f. var. TENERUM (Mettenius) Clausen—PANAMÁ: wet savanna, east of Pacora, June 19, 1938, *Woodson, Allen & Seibert 727.* The first record of this species from Central America.

CYPERACEAE

(H. K. Svenson, Brooklyn, N. Y.)

CAREX LEMANNIANA Boott—CHIRIQUÍ: common on potrero, forming dense tussocks, near summit, Volcán de Chiriquí, alt. ca. 3300 m., July 4–6, 1938, *Woodson, Allen & Seibert 1057.* Reported by Standley (Fl. Costa Rica 1: 96. 1937) as occurring from Costa Rica to Ecuador at altitudes above 2000 m., but apparently never before collected in Panama.

CYPERUS ALBOMARGINATUS Mart. & Schrad.—CANAL ZONE: near Fort Kobe road, July 22, 1938, *Woodson, Allen & Seibert 1427.* Not previously reported from Panama. This number is very peculiar in its light scales; all other material examined from Mexico and Central America has ferruginous scales.

Rynchospora triflora Vahl—panamá: boggy grasslands and marginal thickets between Pacora and Chepo, Aug. 1, 1938, *Woodson, Allen & Seibert 1663.* A widespread tropical species not reported from Central America.

BROMELIACEAE

(L. B. Smith, Cambridge, Mass.)

Tillandsia punctulata Schlechtd. & Cham.—chiriquí: vicinity of Casita Alta, Volcán de Chiriquí, alt. ca. 1500–2000 m., June 28–July 2, 1938, *Woodson, Allen & Seibert 991.* Previously known from southeastern Mexico to Costa Rica, and reported from Surinam.

Vriesia **Woodsoniana** L. B. Smith, spec. nov. (pl. 20), acaulis; foliis rosulatis, ad 5 dm. longis, vaginis ellipticis, basi castaneis, dense punctato-lepidotis, laminis ligulatis, 3 cm. latis, apice rotundato-apiculatis, concoloribus, subtus minute denseque lepidotis, supra glabris; scapo erecto, glabro, vaginis foliaceis dense induto; inflorescentia simplicissima, curvata, subdense pauciflora, ca. 15 cm. longa; bracteis florigeris imbricatis, paulo secunde versis, latissime ovatis, ad apicem versus triangulo-acutis, ad 45 mm. longis et 33 mm. latis, quam sepala longioribus, glabris, valde rugosis, nullo modo carinatis, basi atro-castaneis; floribus valde secundis; pedicellis 1 cm. longis, valde incrassatis; sepalis late ovatis, acutis, 35–40 mm. longis, subtenuibus, impresso-puncticulatis; petalis imperfecte cognitis, basi ligulis binis ad 1 cm. longis auctis; staminibus verisimiliter inclusis.—chiriquí: Bajo Mona, mouth of Quebrada Chiquero, along Río Caldera, alt. ca. 1500–2000 m., July 3, 1938, *Woodson, Allen & Seibert 1029* (Herb. Missouri Bot. Garden, type; Gray Herb., photograph and analytical drawings). In its combination of rugose fioral bracts and secund flowers, *Vriesia Woodsoniana* is quite unlike any previously known species.

JUNCACEAE

Luzula gigantea Desv. var. **vulcanica** Woodson, var. nov., a var. typ. differt foliis angustioribus (0.7–0.9 cm. latis) margine longiuscule denseque ciliatis; tepalis saturate castaneis apice

vix mucronulatis.—CHIRIQUÍ: "El Potrero," Volcán de Chiriquí, alt. ca. 3380 m., July 4–6, 1938, *Woodson, Allen & Seibert 1094* (Herb. Missouri Bot. Garden, TYPE). This is apparently the first record of the species from Panama. Only the forbidding technical difficulties of the genus prevent me from describing var. *vulcanica* as a species, so different does it appear, especially in the foliage, from material that I have seen from Mexico and Costa Rica, and from published plates from South American plants. It forms extensive colonies on the volcanic floor of "El Potrero," immediately beneath the peak of the Volcán de Chiriquí.

MUSACEAE

HELICONIA **nutans** Woodson, spec. nov. (Sect. *Taeniostrobus* O.Ktze.). Herba valida ca. 2-metralis. Folia longe petiolata, petioli 25–30 cm. longi subteretes longitudinaliter striati ca. 0.3 cm. crassi, vagina 20 cm. longa ore membranacea purpurissata, lamina oblongo-elliptica apice abrupte acuminata basi late cordata apice obtusa usque 60 cm. longa 24 cm. lata superne minora utrinque viridis glabra. Inflorescentia longe pedunculata, pedunculo 20–32 cm. longo graciliusculo erecto glabro, rhachi nutanti flexuoso-curvato 15–25 cm. longo ca. 0.4 cm. diam. dense ferrugineo-tomentoso, bracteis 4–7 ambitu lanceolatis latiuscule cymbiformibus apice longe acuminatis basi subamplexicaulibus 6–13 cm. longis 2.0–2.5 cm. latis carinatis rubidulis margine extus minute ferrugineo-hirtellis caeterumque glabris, bracteolis ovatis acuminatis 2–4 cm. longis papyraceis nervo medio ferrugineo-hirtellis caeterumque glabris. Flores in bractearum axillis ca. 4–7, pedicellis ca. 0.2 cm. longis sparse pilosulis, ovario clavato ca. 0.6 cm. longo apice ca. 0.25 cm. crasso glabro, tepalis anguste lanceolatis acuminatis ca. 4.7 cm. longis paulo arcuatis aurantiacis extus margine pilosulis intus omnino pilosulis, staminibus 5, filamentis 5 cm. longis tomentellis, antheris haud visis, staminodio vix 0.3 cm. longo, stylo 5 cm. longo glabro. Capsula ovoidea 1 cm. longa 0.8 cm. crassa glabra atro-violacea.—CHIRIQUÍ: vicinity of Casita Alta, Volcán de Chiriquí, alt. 1500–2000 m., June 28–July 2, 1938, *Woodson, Allen & Seibert 968* (Herb. Missouri Bot. Garden, TYPE).

Apparently most closely related to *H. marginata,* of Darién province, Panama, but differing in the cordate leaves and smaller inflorescence, as well as in technical details of the flowers.

ZINGIBERACEAE

Costus Lima K.Sch.—chiriquí: moist valley thickets, west of Remedios, June 24, 1938, *Woodson, Allen & Seibert 786;* bocas del toro: vicinity of Nievecita, alt. 0–50 m., Aug. 8–19, 1938, *Woodson, Allen & Seibert 1835.* This magnificent species with dark crimson, leafy bracts, which was previously considered as endemic to Costa Rica, was found in numerous localities at low elevations upon both coasts of Panama in Chiriquí and Bocas del Toro. One variation of the species from the latter province, which is distinguished well by its pale pink or flesh-colored bracts, may be described as follows:

Costus Lima K.Sch. var. **Wedelianus** Woodson, var. nov., ab var. typ. bracteis obtusiusculis brevioribus carneisque differt. —bocas del toro: Río Cricamola, between Finca St. Louis and Konkintoë, alt. ca. 10–50 m., Aug. 12–16, 1938, *Woodson, Allen & Seibert 1926* (Herb. Missouri Bot. Garden, type). This variety, which may well merit specific rank, is named in honor of Mr. H. Wedel, the ornithologist of the city of Bocas del Toro, to whom we owe much aid during the trip up the Cricamola River and elsewhere in Bocas del Toro.

Costus argenteus R. & P.—panamá: thickets and forests near Arraiján, alt. ca. 15 m., July 21, 1938, *Woodson, Allen & Seibert 1358;* chiriquí: thickets west of Remedios, June 24, 1938, *Woodson, Allen & Seibert 789.* Considerable confusion has surrounded the identity of this magnificent species, which is common in midsummer in the Canal Zone and occurs elsewhere in the Republic upon both coasts, especially the Pacific. Recorded distribution of *C. argenteus* has been confined to western Peru and Ecuador. All the collections of the species that I have seen have been assigned to *C. villosissimus* Jacq., a very different and common plant of smaller stature and covered everywhere save the flower itself with a long, yellow-hirsute indument. Plate 14 in Standley's "Flora of the Panama

Canal Zone," represents *C. argenteus* rather than *C. villosissimus*. The two species, occurring so commonly together, present strong evidence of hybridization. *Seibert 593,* collected in the vicinity of Gold Creek, near Gamboa, Canal Zone, and distributed as *C. villosissimus,* is a striking example of the putative hybrids.

Recently I have had the good fortune, through the kindness of Professor Domin, of examining the type of *C. hirsutus* Presl *(Haenke s.n.* in Herb. Mus. Nat. Prag.). The specimen appears to me quite conspecific with those more correctly referred to *C. villosissimus* Jacq.

Renealmia exaltata L.f.—bocas del toro: Río Cricamola, between Finca St. Louis and Konkintoë, alt. ca. 10–50 m., Aug. 12–16, 1938, *Woodson, Allen & Seibert 1905.* It is almost incredible that this common and widespread species of the Caribbean and northeastern South America has not previously been reported for Panama. Neither have I seen herbarium specimens from the republic. It is not uncommon in the lowlands bordering the Río Cricamola, and probably is to be found elsewhere along the Atlantic coast.

MARANTACEAE

Calathea **quadratispica** Woodson, spec. nov. Planta valida 2–3 m. alta. Folia longissime petiolata, petioli pars superior paulo compressa callosa 15–17 cm. longa glabra vel minutissime sparseque papillosa pars inferior ca. 75–95 cm. longa, lamina inaequilateraliter ovata basi late obtusa apice rotundata 80–95 cm. longa 47–50 cm. lata utrinque viridis inferne paulo pallidior durius herbacea margine minute puberula caeterumque glabra, vagina scariacea 25–26 cm. longa margine minute puberula. Spicae 2 quadrato-cylindricae 14–15 cm. longae ca. 3 cm. diam., pedunculo 25–30 cm. longo apice dense puberulo in vagina incluso; bracteae distichae 30–34 dense imbricatae latissime ovatae vel suborbiculatae apice rotundatae vel paululo retusae margine vulgo plus minusve revolutae ad 3 cm. longae sparse minuteque pilosulae superne apicem versus densius scariaceae aureae 6–8-florae; paria

florum brevissime (ca. 0.1 cm. vel minus) pedicellatorum 8–12 bracteolis scariaceis exterioribus ca. 2.5 cm. longis ca. 1.2 cm. latis latissime oblongis valde conduplicatis apice truncatis haud profunde 2–4-lobatis interioribus multo minoribus oblongo-lanceolatis acuminatis; ovarium ca. 0.3 cm. longum glabrum vel minute papillatum; sepala oblonga late obtusa 1.7–1.8 cm. longa glabra; corollae flavae tubus anguste cyatho-cylindricus 2.8–3.0 cm. longus basi ca. 0.07 cm. diam., ostio ca. 0.125 cm. diam., lobi ovato-lanceolati acuti ca. 0.8 cm. longi, stamen paululo exsertum 0.3 cm. longum compresse ellipsoideum, staminodium exterius oblique obovatum flavum 1.1 cm. longum, callosum brevius cucullatum 0.7 cm. longum; capsula non visa.—BOCAS DEL TORO: swampy margins of Río Cricamola, between Finca St. Louis and Konkintoë, Aug. 12–16, 1938, *Woodson, Allen & Seibert 1913* (Herb. Missouri Bot. Garden, TYPE). When first studied, this species was thought possibly to represent *C. sclerobractea* K.Sch., which is known to occur only in Guatemala. From the latter, however, and from all other species known to me, *C. quadratispica* differs quite obviously in the rather strongly quadrate-compressed spikes. It is not uncommon in the valley of the Río Cricamola, where it occurs with the familiar *C. lutea* and *C. insignis*.

ORCHIDACEAE

(L. O. Williams, Cambridge, Mass.)

PHRAGMIPEDIUM CAUDATUM (Lindl.) Rolfe, in Orch. Rev. **4**: 332. 1896; Pfitzer, in Engl. Pflanzenr. **IV**. 50 (Heft 12): 52. 1903, in synon.—*Cypripedium caudatum* Lindl., Gen. & Sp. Orch. Pl. 531. 1840; *Selinipedium caudatum* Rchb.f., in Bonplandia **2**: 116. 1854; *Paphiopedilum caudatum* Pfitzer, in Engl. Bot. Jahrb. **19**: 41. 1894; *Paphiopedium caudatum* Kerch., Orch. 454. 1894.—CHIRIQUÍ: vicinity of Casita Alta, alt. 1500–2000 m., June 28–July 2, 1938, *Woodson, Allen & Seibert 962*.

Phragmipedium caudatum has been reported from Chiriquí by Reichenbach (Beitr. Orch. Centr.-Am. 44. 1867), but no specimen was cited by him. The specimen cited above would

seem to be the second collection from Panama. The species is known in Costa Rica, Colombia, Ecuador, and Peru.

The original spelling of the generic name was *Phragmipedium*. Pfitzer changed the spelling to *Phragmopedilum*, in his treatment of the group, and accredited all the combinations to Rolfe except one.[1] This change of the spelling of the generic name is not permissible.

HABENARIA HEPTADACTYLA Rchb.f., in Linnaea **22**: 812. 1849. —PANAMÁ: terrestrial, thickets and forests near Arraiján, alt. about 15 m., July 21, 1938, *Woodson, Allen & Seibert 1406;* without definite locality (Canal Zone or Panama Province), *A. M. Bouché, Jr. 7.*

Habenaria heptadactyla does not seem to have been reported from Panama previously. It is known to occur in Venezuela, British Guiana, and Brazil.

HABENARIA PAUCIFLORA (Lindl.) Rchb.f., in Bonplandia **2**: 10. 1854.—*Habenaria setifera* Lindl., in Ann. Nat. Hist. **4**: 381. 1840.—PANAMÁ: boggy grasslands and marginal thickets, between Pacora and Chepo, alt. about 25 m., Aug. 1, 1938, *Woodson, Allen & Seibert 1665.*

Previously reported from Chiriquí as *H. setifera* by Schweinfurth (Ann. Mo. Bot. Gard. **24**: 182. 1937). This species ranges from Mexico to Argentina.

PONTHIEVA EPHIPPIUM Rchb.f., in Linnaea **28**: 382. 1856.—CHIRIQUÍ: terrestrial, Finca Lérida to Boquete, alt. 1300–1700 m., July 8–10, 1938, *Woodson, Allen & Seibert 1118.*

New to Panama and Central America. Not previously recorded south of the state of Puebla in Mexico.

Ponthieva Ephippium is very closely allied to *P. racemosa* (Walt.) Mohr, but has a lip with two small calluses at the base of the blade and is usually a smaller plant with smaller flowers.

PLEUROTHALLIS VITTATA Lindl., in Bot. Reg. **24**: Misc. 73. 1838; Fol. Orch. Pleurothallis, 18. 1859.—*Pleurothallis poly-*

[1] PHRAGMIPEDIUM **Hartwegii** (Rchb.f.) L. O. Williams, comb. nov.—*Cypripedium Hartwegii* Rchb.f., in Bot. Zeit. **10**: 714. 765. 1852; *Selinipedium Hartwegii* Rchb.f., in Bonplandia **2**: 116. 1854; Xen. Orch. **1**: 3, 70. *t.27.* 1854; *Phragmopedilum Hartwegii* Pfitzer, in Engl. Pflanzenr. **IV.** 50 (Heft 12): 48. 1903.

stachya Rich. & Gal., in Ann. Sci. Nat. III, **3**: 16. 1845; *Pleurothallis mandibularis* Kränzl., in Vid. Medd. Naturh. Foren. **71**: 169. 1920; *Pleurothallis Bourgeaui* Kränzl., in Ark. f. Bot. **16**^{8}: 15. 1920.—COCLÉ: epiphytic, between Las Margaritas and El Valle, July 15–Aug. 8, 1938, *Woodson, Allen & Seibert 1282.*

Pleurothallis vittata is new to the flora of Panama. Previously it has been known from Mexico and Honduras and was reported from Venezuela by Lindley. The record for Venezuela cannot be verified here, as the specimen on which the record was based *(Fendler 1481)* is lacking from the Fendler collection at the Gray Herbarium.

MALAXIS MAJANTHEMIFOLIA Schltr. & Cham., in Linnaea **6**: 59. 1831.—CHIRIQUÍ: terrestrial, vic. of Casita Alta, Volcán de Chiriquí, alt. 1500–2000 m., June 28–July 2, 1938, *Woodson, Allen & Seibert 830.*

Malaxis Majanthemifolia is new to the flora of Panama. The species was previously recorded from Mexico, Honduras, and Guatemala. The flowers of the Panamanian collection are somewhat unusual in that the lateral sepals are adnate almost to their tips.

MALAXIS PARTHONII Morren, in Bull. Acad. Roy. Belg. **5**: 485, *t.* 1838.—CHIRIQUÍ: terrestrial, Finca Lérida to Boquete, alt. 1300–1700 m., July 8–10, 1938, *Woodson, Allen & Seibert 1172;* CANAL ZONE: terrestrial, vic. of Salamanca Hydrographic Station, Río Pequení, alt. about 80 m., July 28–29, 1938, *Woodson, Allen & Seibert 1581.*

Malaxis Parthonii seems not to be recorded from Panama although it is known from Mexico to Costa Rica and again in northern South America.

MALAXIS **Woodsonii** L. O. Williams, sp. nov. (pl. 21, figs. 1–2). Herba nana, terrestris. Caulis brevis, inferne bulbosus, supra medium bifoliatus. Folia subaequalia, late ovata. Inflorescentia subumbelliformis. Segmenta perianthii patentia. Sepala late lanceolata, obtusa. Petala filiformia. Labellum quadratum, apice trilobatum; auriculae lineari-lanceolatae, acutae. Columna minuta.

Small terrestrial herbs up to about 15 cm. tall. Stems short,

swollen and pseudobulbous below, covered with the sheathing petioles of the leaves and by basal bracts. Leaves two, subequal, broadly ovate, obtuse or acute, 1.5–5.5 cm. long and 1.3–4.5 cm. broad, appearing sessile and to be borne well above the middle of the stem but actually with a long petiole which sheathes the stem, margin of the blade crenulate or obscurely serrate, several-nerved. Inflorescence many-flowered; floral bracts short, lanceolate, scarious; pedicels erect or spreading, about 1 cm. long. Sepals broadly lanceolate, obtuse, obscurely 3-nerved, 2.5–4 mm. long and 1.5–2.5 mm. broad, margins strongly recurved, especially on the dorsal sepal. Petals filiform, about 2.5–3 mm. long. Lip quadrate in outline, about 3.5–5 mm. long and 3–3.5 mm. broad; apex of the lip 3-lobed, mid-lobe small, exceeded by the lateral lobes in length, lateral lobes large, rounded, obtuse; the basal auricles linear-lanceolate, acute, 1–2 mm. long, parallel to the axis of the lip, arising well up from the base of the lip; disk with two shallow cavities extending from the base of the column. Column short, about 1 mm. long.—CHIRIQUÍ: terrestrial, vic. of Casita Alta, Volcán de Chiriquí, alt. about 1500–2000 m., June 28–July 2, 1938, *Woodson, Allen & Seibert 831* and *832* (Herb. Ames, Cambridge, Mass., No. 55,715, TYPE).

Malaxis Woodsonii is distinguished from all other American species by the position of the basal auricles of the lip as well as by less obvious characters.

LIPARIS ELATA Lindl., in Bot. Reg. **14**: *t. 1175.* 1828.—CANAL ZONE: epiphytic, vic. of the Salamanca Hydrographic Station, Río Pequení, alt. about 80 m., July 28–29, 1938, *Woodson, Allen & Seibert 1580.*

Although *Liparis elata* does not seem to have been recorded from Panama previously it ranges from Florida, the West Indies, and Mexico, south to northern South America.

EPIDENDRUM **Boothii** (Lindl.) L. O. Williams, comb. nov.—*Maxillaria Boothii* Lindl., in Bot. Reg. **24**: Misc. 52. 1838; *Dinema paleaceum* Lindl., in Bot. Reg. **26**: Misc. 51. 1840; *Epidendrum auritum* Lindl., in Bot. Reg. **29**: Misc. 4. 1843; *Epi-*

dendrum Lindenianum Rich. & Gal., in Ann. Sci. Nat. III, **3**: 20. 1845; *Epidendrum paleaceum* Rchb.f., Beitr. Orch. Centr.-Am. 80. 1860; in Saunders' Ref. Bot. **2**: *t. 87.* 1869; Ames, Hubbard & Schweinf., Genus Epidendrum in U. S. & Mid. Am. 140. 1936; *Nidema Boothii* Schltr., in Fedde Repert. Beih. **17**: 43. 1922.—BOCAS DEL TORO: epiphytic, Río Cricamola, between Finca St. Louis and Konkintoë, alt. about 10–50 m., Aug. 12–16, 1938, *Woodson, Allen & Seibert 1892.*

Epidendrum Boothii is new to the flora of Panama, although it was known in Mexico, throughout Central America except Panama, Cuba, Venezuela and Dutch Guiana.

Ames, Hubbard and Schweinfurth, in their study of *Epidendrum,* did not take up *Maxillaria Boothii,* which is the oldest name for the species, because they supposed that *Epidendrum Boothianum* Lindl. would make a homonym of the combination *Epidendrum Boothii.* This, however, is not the case as *Epidendrum Boothianum* is adjectival in form while *Epidendrum Boothii* is genitive (cf. International Rules of Botanical Nomenclature, ed. 1935, Art. 70, note 4).

EPIDENDRUM ISOMERUM Schltr., in Fedde Repert. **2**: 132. 1906.—BOCAS DEL TORO: epiphytic, pendulous in dense clumps, Río Cricamola, between Finca St. Louis and Konkintoë, alt. about 10–50 m., Aug. 12–16, 1938, *Woodson, Allen & Seibert 1886.*

Epidendrum isomerum does not seem to have been previously reported from Panama, although there is a fragment in the Ames Herbarium collected by G. S. Miller, Jr., near Río Medio in the Canal Zone. Previously recorded from Mexico, Guatemala, Honduras, and Costa Rica.

EPIDENDRUM PRISMATOCARPUM Rchb.f., in Bot. Zeit. **10**: 729. 1852.—CHIRIQUÍ: on fallen logs, Finca Lérida to Boquete, alt. about 1300–1700 m., July 8–10, 1938, *Woodson, Allen & Seibert 1117.*

The type of *Epidendrum prismatocarpum* came from Chiriquí, but there is no record in the Ames Herbarium of the plant having been re-collected in Panama. The species is not uncommon in Costa Rica.

Galeandra Baueri Lindl. in Bauer, Ill. Orch. Pl. Gen. *t. 8.* 1832 (?); Gen. & Sp. Orch. Pl. 187. 1833; in Bot. Reg. **26**: *t. 49.* 1840; Bateman, Orch. Mex. & Guat. *t. 19.* 1840.—*Galeandra Batemanii* Rolfe, in Gard. Chron. III, **12**: 431. 1892.—bocas del toro: in swamp near Almirante, at sea-level, flowered in Panama Aug. 20, 1939, (comm. Paul H. Allen to) *Hugo Nash 1962.*

Galeandra Baueri is new to the flora of Panama. It has been recorded previously from Mexico, British Honduras, Guatemala, Honduras, and French Guiana.

Since Rolfe gave a new name to the Mexican plants in 1892, the name seems to have been universally adopted. Rolfe distinguished *G. Batemanii* as having "a short ovoid pseudobulb, and a dull purple lip" and *G. Baueri* as having "a slender fusiform pseudobulb, and a pale-coloured lip." Most of the Mexican and British Honduran material examined has slender pseudobulbs, but the shape seems to depend on age, the younger ones being slender, the older ones thicker. In regard to the coloration of the flowers it must be remembered that Bauer's drawings were made from a dried specimen which could have lost its color—as have most of the specimens in the Ames Herbarium.

Warrea costaricensis Schltr., in Fedde Repert. **16**: 446. 1920.—chiriquí: terrestrial, deep shade near Potrerillos, 1939, *Allen s.n.;* locality lacking, alt. 3000 ft., 1938, *Kieswetter s.n.*

It is with some hesitation that the above plants are referred to Schlechter's species but it is perhaps best to place them here until the species is better known.

In the specimens cited the lip is oval to round and apparently not emarginate, while Schlechter described and drew the lip of *Warrea costaricensis* as oblong and emarginate. If Schlechter's drawings are correct, there are also differences in the stipe and the gland of the pollinia between the Panamanian plants and Schlechter's specimens, which were from Costa Rica.

Govenia ciliilabia Ames & Schweinf., in Sched. Orch. **10**: 80. 1930.—chiriquí: vic. of Casita Alta, Volcán de Chiriquí, alt. about 1500–2000 m., June 28–July 2, 1938, *Woodson, Allen & Seibert 947.*

Govenia ciliilabia is the rarest species of the genus in Central America. The original and, until now, the only known specimen of the species was collected at Cola de Galla, Costa Rica.

Maxillaria ringens Rchb.f., in Walp. Ann. **6**: 523. 1863; C. Schweinf., in Bot. Mus. Leafl. Harv. Univ. **4**: 91. 1937.—chiriquí: epiphytic, Bajo Mono, mouth of Quebrada Chiquera, along Río Caldera, alt. about 1500–2000 m., July 3, 1938, *Woodson, Allen & Seibert 1010.*

The collection cited above is rather unusual in the large size of the flowers, otherwise it would seem to be quite typical of the species. The sepals are from 5 to 6 cm. long, and the petals are about 4.5 cm. long.

Known previously from Panama; also from Guatemala, Nicaragua, and Costa Rica. The synonyms, *Maxillaria Rousseauae* Schlecht. and *M. pubilabia* Schlecht., were based on Panamanian material.

Rodriguezia compacta Schltr., in Fedde Repert. Beih. **19**: 144. 1923.—bocas del toro: epiphytic, Río Cricamola, between Finca St. Louis and Konkintoë, alt. about 10–15 m., Aug. 12–16, 1938, *Woodson, Allen & Seibert 1888.*

New to Panama. The specimen is past flower but there is little doubt concerning the identity of the plant. Previously recorded from Costa Rica.

Osmoglossum anceps Schltr., in Fedde Repert. Beih. **19**: 147. 1923.—chiriquí: epiphytic, vic. of Casita Alta, Volcán de Chiriquí, alt. about 1500–2000 m., June 28–July 2, 1938, *Woodson, Allen & Seibert 875.*

Previously recorded only from Costa Rica.

Odontoglossum Oerstedii Rchb.f., in Bonplandia **3**: 214. 1855; Xen. Orch. **1**: 189, *t. 68, I.* 1856.—chiriquí: epiphytic on dead logs in dense wet forest, Loma Larga to summit, Volcán de Chiriquí, July 4–6, 1938, *Woodson, Allen & Seibert 1030.*

A handsome small plant previously known only from Costa Rica.

NOTYLIA **Cordesii** L. O. Williams, sp. nov. (pl. 21, figs. 3–4). Herba epiphytica, parva. Folia aequantia, lineari-lanceolata vel lanceolata, acuta vel acuminata. Pseudobulbus parvus, complanatus, unifoliatus. Inflorescentia subumbellata; bracteae scariosae, lanceolatae, acutae vel acuminatae. Sepalum dorsale lineari-lanceolatum, acuminatum, trinervium. Sepala lateralia linearia, acuminata, uni- vel binervia. Petala sepalo dorsali similia sed angustiora, basi trinervia. Labellum unguiculatum; unguis medio biauriculatus; lamina hastata, acuminata; lobi laterales recurvi, serrulati. Columna generis.

A small epiphytic herb. Leaves equitant, laterally flattened, linear-lanceolate to lanceolate, acute or acuminate, sessile, 4–6 cm. long, 3–5 mm. broad (laterally). Pseudobulbs small, complanate, inclosed in the bases of leaves, unifoliolate, 1–1.5 cm. long. Inflorescence a subumbellate raceme, simple or branched; scape from the base of a pseudobulb, slender, about 4–6 cm. long, with several infundibuliform bracts; bracts of the inflorescence scarious, lanceolate, acute or acuminate, about 1.5–2 mm. long, spreading. Pedicels filiform, spreading, with the ovary about 6 mm. long. Dorsal sepal linear-lanceolate, acuminate, 3-nerved, about 10 mm. long and 1.5 mm. broad. Lateral sepals linear, acuminate, slightly oblique, 1–2-nerved, about 12–13 mm. long and 1 mm. broad. Petals similar to the dorsal sepal but slightly narrower, 3-nerved at the base, 1-nerved above. Lip arising at the base of the column but free from it, long-unguiculate, the claw about 4 mm. long, thickened and biauriculate at a point half way between the base of the lip and the lateral lobes, the thickening papillose-pubescent on the anterior side; blade of the lip hastate, acuminate, about 4 mm. long and 2 mm. broad, the lateral lobes recurved, serrulate, the apex strongly acuminate. Column slender, about 3 mm. long, characteristic of the genus.—BOCAS DEL TORO: epiphytic, Mosquito Hill, Aug. 12–16, 1938, (comm. by Dr. H. Cordes to) *Woodson, Allen & Seibert 1932* (Herb. Missouri Bot. Garden, TYPE).

Notylia Cordesii is allied to several of the Central American species of the genus, among them *N. bicolor* Lindl., *N. linearis* A. & S., *N. ramonensis* Schltr., and *N. Wullschlaegeliana* Rchb.f. It is most closely allied to the last of these, *N. Wullschlaegeliana,* from which it may be distinguished as a larger plant with distinctly larger leaves and flowers; by having the lip entirely free from the column; by having the auricles near the middle of the claw instead of at the base.

It is a pleasure to name this fine little orchid for Dr. Cordes, who has shown much interest in the flora of Panama.

Telipogon ampliflorus C. Schweinf., in Bot. Mus. Leafl. Harv. Univ. **6**: 34. 1938.—chiriquí: epiphyte, vic. of Casita Alta, Volcán de Chiriquí, alt. about 1500–2000 m., June 28–July 2, 1938, *Woodson, Allen & Seibert 961.*

Telipogon ampliflorus, which was recently described from Costa Rica, is new to the flora of Panama. The flowers of the present specimens are somewhat smaller than those described by Schweinfurth.

ROSACEAE

(Alchemilla by L. M. Perry, Jamaica Plain, Mass.)

Alchemilla pectinata HBK.—chiriquí: vicinity of Casita Alta, Volcán de Chiriquí, alt. 1500–2000 m., common in clearings, June 30, 1938, *Woodson, Allen & Seibert 892;* Loma Larga to summit, Volcán de Chiriquí, alt. 2500–3380 m., July 5, 1938, *Woodson, Allen & Seibert 1042.* Known to extend from Mexico to Colombia and Bolivia, but previously unknown from Panama. No. *1042* is a typical specimen; *892* is a more stoloniferous and smallish specimen, but apparently belongs to this species.

Alchemilla aphanoides L.f. var. subalpestris (Rose) Perry—chiriquí: Loma Larga to summit, Volcán de Chiriquí, alt. 2500–3380 m., July 5, 1938, *Woodson, Allen & Seibert 1041.* Originally described from Mexico. I have not seen previously this plant from farther south than Costa Rica. Reported by Standley (Fl. Costa Rica **2**: 477. 1937) as extending to Bolivia.

Hesperomeles **chiriquensis** Woodson, spec. nov. Arbuscula dense ramosa 1.5–3.0 dm. alta; ramis sat crassis subfastigiatis; ramulis juventate dense minuteque fulvo-hispidulis mox glabratis haud spinescentibus, internodiis 0.1–0.4 cm. longis; foliis plerumque obovato-suborbicularibus apice rotundatis vel paulo retusis rare subacutis basi late cuneatis 0.3–2.0 cm. longis 0.2–1.9 cm. latis margine inconspicue depresso-serrulatis coriaceis supra paulo illustris nervo medio dense minuteque fulvo-hispidulis subtus pallidioribus opacis nervo medio sparse hispidulis caeterumque glabris; petiolo 0.2 cm. longo fulvo-hispidulo; inflorescentiis corymbosis densis plurifloris; bracteis subfoliaceis lanceolatis 0.4–0.8 cm. longis; pedicellis subnullis; cupulis late conicis 0.3 cm. longis 0.35 cm. latis extus fulvo-hispidulis intus dense villosulis; sepalis triangulo-setosis 0.35 cm. longis ut in cupula vestitis; petalis obovato-oblongis 0.5 cm. longis 0.4 cm. latis basi unguiculatis pallide roseis; staminibus 20, filamentis 0.15–0.3 cm. longis, antheris 0.07 cm. longis; pistillis 0.5 cm. longis basi villosulis; fructu ignoto.—CHIRIQUÍ: Loma Larga to summit, Volcán de Chiriquí, alt. ca. 3300 m., July 4–6, 1938, *Woodson, Allen & Seibert 1078* (Herb. Missouri Bot. Garden, TYPE).

This handsome dwarf tree was found almost literally covered with its pale pink flowers, not far below the summit of the volcano. *H. obovata* (Pittier) Standl., of the neighboring peaks of Costa Rica, is distinguished from it by its white, smaller petals, and spinescent twigs. The extremely dwarf stature and very crowded foliage, probably induced by the high altitude, are also distinctive, as well as the depressed serrulation of the leaves.

POLYGALACEAE

(S. F. Blake, Washington)

Monnina xalapensis HBK.—CHIRIQUÍ: vicinity of Casita Alta, Volcán de Chiriquí, alt. 1500–2000 m., June 28–July 2, 1938, *Woodson, Allen & Seibert 802*. Apparently new to Panama; previously known from Vera Cruz to Nicaragua and Costa Rica.

EUPHORBIACEAE

(P. C. Standley, Chicago)

Croton **Allenii** Standl., sp. nov. Arbuscula 4-metralis ramosa, ramis gracilibus teretibus ochraceis sparse pilis stellatis sessilibus pauciradiatis pilosis, sat dense foliatis, internodiis brevibus vel elongatis; stipulae filiformi-subulatae 1.5–2 mm. longae apice glanduliferae deciduae; folia inter minora longipetiolata herbacea, petiolo gracili 2–3.5 cm. longo sparse stellato-piloso; lamina ovata vel oblongo-ovata 5–8 cm. longa 2.5–4.5 cm. lata acuta vel subabrupte breviter acuminata, basi late rotundata atque breviter cordata, arcte crenato-serrulata, utrinque viridis, sparsissime praesertim ad nervos stellato-pilosa, e basi 5-nervia, nervo medio supra basin utroque latere nervos ca. 4 emittente; flores monoeci racemosi, racemis terminalibus breviter pedunculatis 4–7 cm. longis laxe remotifloris, rhachi sat dense stellato-pilosa, pedicellis 1–3 mm. longis; flores fertiles pauci vulgo 1–2, interdum usque 6, sepalis 5 in statu fructifero 5–6 mm. longis subaequalibus lanceolato-oblongis acutis remote serratis dense stellato-pilosis erectis, petalis nullis; styli bis dichotome divisi glabri; flores masculi numerosi cito decidui in alabastro globosi atque 2.5 mm. diam., sparse stellato-pilosi; stamina ca. 10, filamentis glabris; capsula vix matura 5 mm. longa ubique dense pilis parvis patentibus stellato-pilosa.—coclé: vicinity of Antón, Aug. 8, 1938, *Woodson, Allen & Seibert 1711* (Herb. Field Mus., type; duplicate in Herb. Missouri Bot. Garden).

A notable addition to the rather few species of *Croton* known from Panama, distinctive in appearance because of its rather small and bright green leaves, which at first sight appear to be glabrous. The hairs of the pubescence vary considerably in form, but many of them are distinguished by having short basal rays and very long and soft central ones.

Plukenetia volubilis L.—los santos: thickets between Los Santos and Guararé, July 11, 1938, *Woodson, Allen & Seibert 1201.* Apparently known from Central America only by this specimen. It is recorded or represented also from Dominica,

Colombia, Peru, and Bolivia. At least one other species of the genus occurs in northern Central America.

DILLENIACEAE

(P. C. Standley, Chicago)

SAURAUIA **Seibertii** Standley, sp. nov. Arbor, ramulis crassiusculis fere glabris sed sparsissime atque fere minute adpresso-furfuraceis; folia petiolata crassiuscula atque in sicco rigidula, petiolo 1.5–3.5 cm. longo sparse adpresso-furfuraceo; lamina oblongo-lanceolata 15–20 cm. longa 4.5–5.5 cm. lata acuminata, basin acutam versus paullo angustata, in toto margine arcte serrata, supra sublucida glaberrima, subtus ad nervos sparsissime adpresso-furfuracea, costa crassiuscula elevata, nervis lateralibus utroque latere ca. 15 angulo semirecto vel paullo latiore adscendentibus prominentibus teneris; paniculae axillares longipedunculatae folia aequantes vel paullo longiores, pedunculo usque 15 cm. longo minute sparse tomentello atque sparse adpresso-furfuraceo, paniculis amplis sublaxe multifloris ca. 12 cm. longis atque aequilatis, ramis dense tomentellis et sparse breviter furfuraceis, bracteis conspicuis interdum foliaceis angustis, pedicellis gracilibus dense tomentellis usque 15 mm. longis; sepala rotundato-ovata vel late elliptica ca. 8 mm. longa apice obtusa vel rotundata, utrinque densissime minute tomentella; petala alba glabra rotundato-elliptica vel ovalia ca. 14 mm. longa—CHIRIQUÍ: Bajo Mono, mouth of Quebrada Chiquero, along Río Caldera, alt. 1500–2000 m., "common along Río Caldera," July 3, 1938, *Woodson, Allen & Seibert 1020* (Herb. Field Mus., TYPE; duplicate in Herb. Missouri Bot. Garden).

The practically glabrous, rather coarsely and regularly serrate leaves of this plant isolate it among the various Panama species of *Saurauia*. It is not closely similar to any of the rather numerous species occurring in Costa Rica.

TILIACEAE

LUEHEA CANDIDA (Moc. & Sessé) Mart.—COCLÉ: llanos between Aguadulce and Antón, alt. ca. 15–50 m., July 12, 1938, *Woodson, Allen & Seibert 1203.* A handsome tree 10–15 m.

tall, bearing showy, white flowers. Not infrequent in the locality visited, but apparently not previously reported from Panama.

BUXACEAE

(C. L. Lundell, Ann Arbor, Mich.)

Buxus citrifolia Spreng.—canal zone: vicinity of Salamanca Hydrographic Station, Río Pequení, alt. ca. 80 m., July 28–29, 1938, *Woodson, Allen & Seibert 1563.* This interesting shrub has not been known previously to occur in Central America, having been collected or reported only in Cuba, Puerto Rico, and Venezuela.

CELASTRACEAE

(C. L. Lundell, Ann Arbor, Mich.)

Maytenus **Woodsoni** Lundell, sp. nov. (pl. 22). Arbor 3 m. alta. Ramuli verticillati, breves et crassiusculi, striati, glabri. Folia glabra, coriacea, obovata, oblanceolata, oblanceolato-oblonga vel elliptica, 4–8 cm. longa, 1.8–4.1 cm. lata, vel interdum minora, apice acuta, obtusa vel rotundata, basi late cuneata, revoluta, supra mediam serrulata, venis utrinque 6 vel 7, reticulatis; petiolis 3–5 mm. longis. Flores fasciculati. Pedicelli usque ad 5 mm. longi, glabri. Calyx quinquefidus, lobis laciniatis, late ovatis vel suborbicularibus, 1.2–1.8 mm. longis, glabris. Petala vinacea, late ovata vel suborbicularia, usque ad 2.5 mm. longa, erosa. Stamina 5. Ovarium 3-loculare, ovulis in loculis solitariis. Pedicelli fructiferi 3.5–6 mm. longi. Capsula late obovoidea, 6–7 mm. longa. Semina 1 vel 3, arillata, obovoidea, ca. 4.5 mm. longa.

A tree 3 m. high; branchlets verticillate, rather short and stout, striate and angled, glabrous; buds covered with rufous-laciniate scales. Leaves glabrous, subverticillate at apex of branchlets, alternate otherwise. Stipules ligulate, up to 2.5 mm. long, maroon, long-laciniate. Petioles stout, 3 to 5 mm. long, shallowly grooved above. Leaf blades coriaceous to rigidly coriaceous, obovate, oblanceolate, oblanceolate-oblong or elliptic, usually 4 to 8 cm. long, 1.8 to 4.1 cm. wide, sometimes smaller, apex acute to rounded, base broadly cuneate, margin slightly revolute, conspicuously serrulate above the middle,

the serratures rounded and apiculate with short red inflexed teeth, costa prominent and rather thick beneath at base, slender toward apex, slightly elevated above, main lateral veins 6 or 7 on each side, prominulous beneath, plane or slightly impressed above, veinlets reticulate and prominulous beneath. Inflorescence usually at leafless nodes, reduced to a fascicle, the bracteoles of the reduced inflorescence persistent at base of pedicels, maroon, lacinate, forming a compact protuberance. Pedicels up to 5 mm. long, glabrous. Calyx deeply 5-lobed, the lobes red, laciniate, broadly ovate or suborbicular, 1.2 to 1.8 mm. long including fringe, glabrous. Petals vinaceous, broadly ovate or suborbicular, up to 2.5 mm. long, margin erose and colorless. Stamens 5. Ovary 3-celled, with 1 erect ovule in each cell. Fruiting pedicels 3.5 to 6 mm. long, jointed near base. Capsules broadly obovoid, 6 to 7 mm. long, 3-celled, 1- to 3-seeded. Seed arillate, obovoid, about 4.5 mm. long; endosperm copious; cotyledons 2.7 mm. long; radicle stout, terete, about 1 mm. long.—CHIRIQUÍ: Loma Larga to summit, Volcán de Chiriquí, alt. 2500–3380 m., July 4–6, 1938, *Woodson, Allen & Seibert 1065* (Herb. Univ. Michigan, TYPE in flower); same locality, *Woodson, Allen & Seibert 1088* (Herb. Univ. Michigan, COTYPE, in fruit).

M. Woodsoni approaches *M. verticillata* (R. & P.) DC., a species of Peru with varieties in Ecuador and Colombia. The Panama tree may be distinguished by its conspicuously serrulate leaves, fascicled flowers, much larger maroon calyx-lobes, and vinaceous petals. The laciniate margin of the stipules, bracts, and calyx-lobes is a noteworthy characteristic shared apparently by *M. verticillata.* The flowers appear to be dioecious, but from the material available I have not been able to determine this point definitely.

MYRSINACEAE

(C. L. Lundell, Ann Arbor, Mich.)

PARATHESIS **Seibertii** Lundell, sp. nov. Arbor 4–6 m. alta. Ramuli crassiusculi, minute et parce adpresse rufo-lepidoti. Folia anguste oblonga vel oblongo-elliptica, 8.5–19 cm. longa, 2.2–4.6 cm. lata, apice basique acuminata, margine subrepanda

vel integra, membranacea, supra glabra, subtus parce et minute lepidota, nervis patentibus, fere 18-jugis, prominulis, punctulis multis (pleris breviter lineiformibus) auctis; petiolis 1.5–2.5 cm. longis. Inflorescentiae axillares, multiflorae, paniculatae, thyrsoideae, 8–9 cm. longae, parce lepidotae vel glabrae, pedicellis usque ad 6.5 mm. longis, quam bracteis multo longioribus; flores ante anthesin ca. 5 mm. longi, minute rufopuberuli; sepala basi coalita, anguste triangularia, ca. 0.9 mm. longa, punctata; petala intus tomentosa, anguste lanceolato-attenuata, 5 mm. longa, basi coalita, punctata; stamina 3–3.2 mm. longa, antheris apiculatis, 1.7–2 mm. longis, dorso parce (1–4) atro-punctulatis, filamentis glabris, supra basin affixis; ovarium ad apicem minute rufo-tomentellum; stylus basi breviter pilosus.

A tree 4 to 6 m. high. Branchlets rather thick, at first minutely appressed rufous-lepidote. Leaves with petioles 1.5 to 2.5 cm. long, narrowly oblong or oblong-elliptic, 8.5 to 19 cm. long, 2.2 to 4.6 cm. wide, apex and base acuminate, margin somewhat repand, nearly entire, membranaceous, glabrous above, sparsely and minutely lepidote below, main lateral veins usually 18 on each side, nearly horizontal, prominulous on under-surface, picta numerous, mostly short-linear. Inflorescence axillary, many-flowered, paniculate, thyrsoid, 8 to 9 cm. long, sparsely lepidote or glabrous, pedicels up to 6.5 mm. long, much exceeding bracteoles; flowers before anthesis about 5 mm. long, finely rufous-puberulent; sepals united at base, narrowly triangular, about 0.9 mm. long, punctate; petals tomentose within, narrowly lanceolate-attenuate, 5 mm. long, united at base, linear-punctate; stamens 3 to 3.2 mm. long, anthers apiculate, 1.7 to 2 mm. long, dorsally few (1–4), black-punctate, filaments glabrous, subequaling anthers, attached slightly above base of petals; ovary rufous-tomentellous at apex, base of style short-pilose.—CHIRIQUÍ: valley of the upper Río Chiriquí Viejo, alt. 1300–1900 m., July 27, 1937, *Peggy & Gene White 27* (Herb. Univ. Michigan, TYPE).

Another collection, *Woodson, Allen & Seibert 798,* from vicinity of Casita Alta, Volcán de Chiriquí, Province of Chiri-

quí, Panama, June 28–July 2, 1938, at alt. of 1500–2000 m., is referable here, but differs in having smaller narrowly elliptic leaves. These collectors describe the fruits as "purple-black, depressed spherically, 1.2 cm." in diam. The flowers are reported to be pale pink or pink with sweet odor.

P. Seibertii is closely related to *P. melanosticta* (Schlechtd.) Hemsl., a species of Mexico and northern Central America, from which it may be differentiated by the entire or slightly repand, narrower, very thin, predominantly oblong leaves, and the paucity of pubescence throughout. The other related species, *P. macrophylla* Rusby of Bolivia, has much smaller anthers shorter than the filaments, as well as other marked differences.

VITACEAE

Cissus erosa L. C. Rich.—coclé: thickets between Las Margaritas and El Valle, Aug. 8, 1938, *Woodson, Allen & Seibert 1763*. *C. erosa* is abundant in the Antilles, and has been collected several times in British Guiana, but this is apparently its first record in Central America. It was seen but once in the vicinity where the collection was made.

GUTTIFERAE

(P. C. Standley, Chicago)

Hypericum **Woodsonii** Standley, sp. nov. Herba perennis dense caespitosa omnino glabra, caulibus numerosis 3–8 cm. longis suberectis, saepe plus minusve intertextis angulatis dense foliatis; folia parva internodiis multo longiora sessilia oblonga vel oblanceolato-oblonga obtusa vel subacuta plerumque 3–8 mm. longa, basin versus paullo cuneato-angustata dense punctata, marginibus saepe plus minusve revolutis; flores terminales solitarii breviter pedunculati; sepala viridia 4–5 mm. longa tenuiter nervata anguste oblonga, apice apiculato-acutata; petala lutea sepalis aequilonga; styli 3 erecti 1 mm. longi et ultra; capsula ovoideo-oblonga 4 mm. longa apice in stylos sensim attenuata 1-locularis; semina numerosa oblonga ochracea 0.6 mm. longa.—chiriquí: forming mats on potrero, Loma Larga to summit, Volcán de Chiriquí, alt. 2500–3380 m., July 4–6, 1938, *Woodson, Allen & Seibert 1040* (Herb. Field

Mus., TYPE; duplicate in Herb. Missouri Bot. Garden). Prostrate in potrero, Potrero Muleto, Volcán de Chiriquí, 3120 m., July 19, 1938, *Mrs. M. E. Davidson 1048* (Herb. Field Mus.).

From all other species of *Hypericum* known from southern Central America this is conspicuously different in its low, depressed habit, the plant being perennial and forming dense, interlaced mats.

MYRTACEAE

(P. C. Standley, Chicago)

EUGENIA **salamancana** Standley, sp. nov. Arbor 6-metralis, ramulis crassiusculis rigidis teretibus, novellis dense pilis brevibus rigidulis patentibus pilosis, internodiis brevibus; folia mediocria breviter petiolata subcoriacea, petiolo crasso 5–7 mm. longo dense breviter piloso; lamina oblonga vel ovali-oblonga 7–9 cm. longa 2.5–4 cm. lata, apice rotundata atque subito caudato-acuminata, acumine ca. 1 cm. longo angusto attenuato, basi anguste rotundata, supra subopaca, ad costam subimpressam minute pilosula, aliter glabra, nervis venisque obsoletis, subtus fere concolor, ad costam prope basin laminae pilosa, aliter glabra, costa gracili elevata, nervis lateralibus utroque latere ca. 12 sed obscuris, venis omnino occultis; flores ut videtur e ramis defoliatis nascentes solitarii(?) sessiles vel brevissime pedicellati, perfecti non visi.—CANAL ZONE: vicinity of Salamanca Hydrographic Station, Río Pequení, alt. 80 m., July 28–29, 1938, *Woodson, Allen & Seibert 1570* (Herb. Field Mus., TYPE; duplicate in Herb. Missouri Bot. Garden).

In leaf characters the species is unlike any other known from the region of the Isthmus, the nervation, except for the costa, being obscure or obsolete. The form of the inflorescence, although its structure is not well established, likewise appears to be quite distinctive.

MELASTOMACEAE

(H. A. Gleason, New York)

CENTRONIA PHLOMOIDES Triana—CHIRIQUÍ: vicinity of Casita Alta, Volcán de Chiriquí, alt. ca. 1500–2000 m., June 28–July 2, 1938, *Woodson, Allen & Seibert 842.* Previously known from Costa Rica.

Miconia lindenii Naud.—chiriquí: Finca Lérida to Boquete, alt. ca. 1300–1700 m., July 8–10, 1938, *Woodson, Allen & Seibert 1143.* Previously known from Costa Rica and Venezuela.

Blakea **Woodsoni** Gleason, sp. nov. (Sect. *Pyxidanthus*). Arbuscula 5–7 m. alta. Rami irregulariter 4-angulati, internodiis circa 10 mm. longis paulo incrassatis, superne furfuraceo-hispidi, pilis curvatis crasse subulatis fere 1 mm. longis. Petioli crassi, 12–25 mm. longi, sicut rami sparse hispidi. Laminae chartaceae obovato-oblongae, usque 11 cm. longae 7 cm. latae, apice subrotundatae ad apiculum triangularem brevem, integrae, basi late cuneatae, vix 3-pli-nerviae, supra glabrae arctissime brunneo-punctulatae, subtus hinc inde brevissime hispidulae, praecipue ad venas. Flores solitarii ex axillis superioribus, pedicello 6 cm. longo, hispidulo, glabrescenti. Bracteae per paria connatae, pari exteriori 12 mm. longo primo hispidulo mox glabrescenti, margine vix 2-lobato; bracteae interiores quam exteriores 3 mm. longiores, glabrae, margine integro. Calyx quam bracteae interiores 7 mm. longior, glaber, lobis 6, semicircularibus, paulo retusis et tuberculato-apiculatis. Petala anguste triangulari-obovata, alba, 4 cm. longa. Antherae semi-ovatae 7 mm. longae. Stylus gracilis, ad stigma punctiforme angustatus.—chiriquí: vicinity of Casita Alta, Volcán de Chiriquí, alt. 1500–2000 m., July 1, 1938, *Woodson, Allen & Seibert 951* (Britton Herb., New York Bot. Garden, type). It is at once distinguished from other Panama species by its totally connate bracts. The hairs of the stem, peduncles, and bracts are very easily detached.

LECYTHIDACEAE

Gustavia brachycarpa Pittier, Contr. U. S. Nat. Herb. **26**: 3. 1927.—chiriquí: swampy forests, west of Remedios, June 24, 1938, *Woodson, Allen & Seibert 787.* As far as we are aware, this is the first record of this peculiar specimen since the collection of the type by Pittier in 1911. The specimens of Pittier, from near San Felix, in the same general vicinity of our trees, were in fruit only. Ours are in full flower and young fruit. In bloom, the trees of *G. brachycarpa* are by far the most showy

of the low forests of the country-side. The petals are pure white, 6, broadly obovate-oblong, and somewhat unequal, 4.5–5.0 cm. long, 2.2–2.5 cm. broad, broadly rounded, essentially glabrous within, but very densely and minutely puberulent-papillate without. The stamens are exceedingly numerous, forming a regular, involuted cup 1.5 cm. deep; the anthers are connivent, oblongoid, 0.2 cm. long, and dehisce apically. The handsome flowers are borne singly or in pairs, and are slightly fragrant. Pittier's description of the leaves, fruits, and branches is accurate, and corresponds very closely to our specimens.

VACCINIACEAE

(W. H. Camp, New York)

Comarostaphylis **chiriquensis** Camp, sp. nov. Frutex 1–3 m., ramis pubescentibus; folia rectangulo-ovata, petiolo 5–8 mm. longo, basi cuneata vel acuta, apice acuta, subcoriacea, 5–6 cm. longa, 1.0–1.5 cm. lata, supra glabra, subtus in foliis adultis dense ferrugineo- vel griseo-lanata, margine obscure undulata vel integerrima, revoluta; inflorescentia terminalis, paniculata, ubique obscure albido-puberula et plus minusve ferrugineo-pilosa, pilis glandulosis; pedicelli 2–3 mm. longi; bractea subacuminata; calyx 5-lobus, lobis ovato-acuminatis circ. 1.5 mm. longis, puberulis et sparse glandulosis; corolla globoso-urceolata, circ. 5 mm. longa, alba, extra obscure farinacea vel puberula, intra puberula, apice manifeste contracta, breviter 5-lobata, lobis puberulis; stamina 10, filamentis basin versus dilatatis, dense pubescentibus, circ. 2 mm. longis, antheris circ. 1.5 mm. longis, bicornutis; ovarium elongato-globosum, pubescens.—CHIRIQUÍ: Loma Larga to summit, Volcán de Chiriquí, alt. ca. 2500–3380 m., July 4–6, 1938, *Woodson, Allen & Seibert 1033* (Britton Herb., New York Bot. Garden, TYPE).

This species, although closely related to *C. arbutoides* Lindl., may be distinguished from it by the greater number of conspicuous gland-hairs on the rachis and pedicels, these often being 1 mm. long, and the absence of the rusty-brown, woolly tomentum on these same structures—a characteristic feature

of *C. arbutoides*. In this last, all the inflorescence and often the floral structures are so covered with this tomentum that their surfaces are invisible, whereas in *C. chiriquensis* this is not the case. An additional interesting feature of this new species is the presence on the lower surface of the leaf of scattered gland-hairs on and near the midvein as well as on the petioles. Minute fruiting bodies of some fungus, similar in appearance to these glands, but easily recognizable as such, are also present on various organs of the type.

GENTIANACEAE

(F. P. Jonker, Utrecht; Halenia by C. K. Allen, Jamaica Plain, Mass.)

LISIANTHUS CHELONOIDES L.f.—CHIRIQUÍ: Finca Lerida to Boquete, alt. ca. 1300–1700 m., July 8–10, 1938, *Woodson, Allen & Seibert 1111*. Previously recorded from Peru, Brazil, the Guianas, and the West Indies.

SCHULTESIA BRACHYPTERA Cham. forma HETEROPHYLLA (Miq.) Jonk.—PANAMÁ: boggy grasslands and marginal thickets, between Pacora and Chepo, alt. ca. 25 m., Aug. 1, 1938, *Woodson, Allen & Seibert 1647*. Previously known from Brazil, Venezuela, the Guianas, and Mexico.

HALENIA **Woodsoniana** C. K. Allen, spec. nov. Herba perennis (?), caule basi ramoso procumbente; ramulis floriferis pluribus erectis usque ad 7 dm. altis; ramulis sterilibus foliosis quam ramulis floriferis circiter ½ brevioribus (± 3 dm. altis); internodiis inferioribus brevibus (1.5–3 cm.) superioribus longioribus (4–6.5 cm.); foliis sessilibus lineari-lanceolatis acuminatis leviter 3-nerviis, nervo medio prominente, usque ad 6 cm. longis et 0.7 cm. latis; inflorescentia terminalis axillarisve cymosa laxa pauciflora; calyce usque ad 1 cm. longo et ad ca. ¾ corollae longitudinem aequante; lobis 3-nerviis lanceolatis acuminatis; corollae lobis ovalibus acutis leviter erosis; calcaribus usque ad ⅓ corollae longitudinem aequantibus horizontalibus ad leviter ascendentibus; staminibus 0.5 cm. longis; capsula late lanceolata usque ad 1.7 cm. longo.—CHIRIQUÍ: Volcán de Chiriquí, ca. 2500–3380 m., Loma Larga to summit, July 4–6, 1938, *Woodson, Allen & Seibert 1052* (Herb. Missouri Bot. Garden, TYPE).

The above species is distinctive because of the much-branched stem, somewhat procumbent at the base, the short leafy sterile shoots arising from the main stem, and the tall spreading, loosely flowered inflorescence, the pedicels of which are often pendulous. The species, the sole representative of the genus in Panama thus far found, is most closely related to *Halenia rhyacophila* Allen from Costa Rica.

APOCYNACEAE

RAUWOLFIA HIRSUTA Jacq. var. **glabra** (Muell.-Arg.) Woods. comb. nov. (*R. canescens* L. var. δ *glabra* Muell.-Arg. Linnaea **30**: 394. 1860).—PANAMÁ: Isla Taboga, thickets near sea-level, July 23–24, 1938, *Woodson, Allen & Seibert 1530.*

FORSTERONIA SPICATA (Jacq.) G. F. W. Meyer—PANAMÁ: Isla Taboga, abundant, in thickets along rocky shore, July 23–24, 1938, *Woodson, Allen & Seibert 1551.* This species is of interest since it is predominantly a Caribbean element found at intervals upon the continent from southern Mexico to northern Colombia, and in Cuba. Upon the Pacific coast it has been reported only from Salvador and Costa Rica. This is the first record of the species from Panama.

STEMMADENIA OBOVATA (H. & A.) K.Sch. var. MOLLIS (Benth.) Woods.—LOS SANTOS: between Los Santos and Guararé, July 11, 1938, *Woodson, Allen & Seibert 1200;* vicinity of Las Tablas, alt. 15 m., Sept. 12, 1938, *Allen 812.* Previously recorded from southern Mexico to Costa Rica, where it is relatively limited in distribution; also very local in western Ecuador.

PRESTONIA **remediorum** Woodson, spec. nov. Frutex volubilis, ramis ramulisque crassiusculis ferrugineo-hirtis. Folia obovato-elliptica apice breviter acuminata basi obtuse cuneata 15–18 cm. longa 9–11 cm. lata membranacea opaca supra subtusque ferrugineo-pilosula, petiolis 1.5 cm. longis, appendicibus stipulaceis intrapetiolaribus pectinatis ca. 0.25 cm. longis. Inflorescentia lateralis simplex pluriflora corymbiformis folia ca. ½ aequans, pedicellis ca. 1 cm. longis ferrugineo-hirtellis, bracteis foliaceis oblongo-lanceolatis acuminatis 1.0–1.5 cm. longis foliaceis ferrugineo-puberulis. Calycis

lobi oblongo-lanceolati acuminati 1.7–1.8 cm. longi foliacei dense ferrugineo-hirtelli, squamellis profunde pectinatis subcallosis ca. 0.2 cm. longis appendicibus stipulaceis similibus. Corollae luteae extus dense ferrugineo-velutinae tubus subinfundibuliformis in alabastrum submaturum 2 cm. longus basi ca. 0.15 cm. diam., faucibus ca. 0.35 cm. diam.; lobi obovato-dolabriformes acuminati 1.7 cm. longi. Anthera 0.7 cm. longa glabra apice paululo exserta. Stigma fusiforme 0.3 cm. longum; ovarium ovoideum ca. 0.15 cm. altum glabrum; nectaria 5 carnosa basi concrescentia ovarium aequantia. Folliculi ignoti.—CHIRIQUÍ: thicket, between Río Chiriquí and Remedios, alt. ca. 15–50 m., July 11, 1938, *Woodson, Allen & Seibert 1180* (Herb. Missouri Bot. Garden, TYPE).

When this species was collected, it was mistaken for *P. isthmica* Woods., an endemic of Costa Rica. The leaves of *P. remediorum* are quite distinct, however, by reason of their cuneate base, and the conspicuous, pectinate calycine squamellae are quite unlike those of any species with which I am familiar.

FERNALDIA **speciosissima** Woodson, spec. nov. Frutex volubilis alte scandens, nec foliis nec calycibus necque ovariis visis; corollae speciosissimae albidae extus omnino glaberrimae tubo proprio 2.5–2.8 cm. longo basi ca. 0.25 cm. diam. stricto haud gibboso, faucibus tubulosis 2.6–2.8 cm. longis intus dense arachnoideo-villosis, ostio ca. 0.6 cm. diam., lobis oblique obovatis obtusis 2.8–3.0 cm. longis patulis utrinque glaberrimis; antheris anguste lanceolato-sagittatis basi obtuse auriculatis 1 cm. longis glaberrimis; stigmate fusiformi basi minute digitato-appendiculato 0.3 cm. longo.—CHIRIQUÍ: thickets, between Río Chiriquí and Remedios, alt. 15–50 m., July 11, 1938, *Woodson, Allen & Seibert 1179* (Herb. Missouri Bot. Garden, TYPE).

It is exasperating to have to describe this species merely from several detached corollas found at the base of a tall tree supporting the liana. Efforts to obtain more ample material being futile at the time of collection, complete confidence none the less may be placed in the generic identification of the corollas (which, of course, contain the stamens and stigma as

is customary in the Echitoideae). The anthers, stigma, and arachnoid internal villosity of the corolla are all unmistakable characters, although the villosity differs from that of the three other known species of the genus in being limited to the throat. The corollas of *F. speciosissima* much surpass those of the other known species, and the narrowly tubular throat is quite distinct. Eastern Chiriquí is one of the least known and most promising floristic regions of Panama, as is graphically illustrated by the discovery of both *Prestonia remediorum* and *Fernaldia speciosissima,* literally within a stone's throw of one another.

ASCLEPIADACEAE

Macroscepis **panamensis** Woodson, spec. nov. (fig. 1). Suffrutex volubilis; ramis dense luteo-pilosis pilis dissimilibus tum brevibus simplicibus tum multo longioribus multicellularibus sicut ad petiolos et pedunculos pedicillosque; foliis oppositis petiolatis latissime ellipticis vel obovato-ellipticis apice attenuate subcaudato-acuminatis basi late auriculatis 14–17 cm. longis 9–11 cm. latis membranaceis opacis supra sparse strigosis subtus farinulento-puberulis nervo medio subtus luteo-pilosis, petiolo 2 cm. longo; inflorescentiis axillaribus alternatis umbelliformibus 6–8-floris, pedunculo ca. 2 cm. longo; bracteis lineari-lanceolatis foliaceis ca. 1 cm. longis vel infra dense luteo-pilosis; pedicellis 0.8 cm. longis similiter vestitis; calycis laciniis late ellipticis acuminatis foliaceis 0.5–0.6 cm. longis minute puberulis margine ciliatis intus eglandulosis; corollae salverformis extus omnino glaberrimae pallide luteo-viridis tubo campanulato 0.9–1.0 cm. longo medio inflato ibique ca. 0.8 cm. diam. faucibus constrictis minute hispidulis ceterumque glaberrimis, limbo patulo 1.8–1.9 cm. lato intus minute hispidulo-papillato ca. dimidio lobato lobis obtusis, coronae squamis tubo fere ad fauces adnatis apice subquadratis integris introrsum replicatis basi calloso-geniculatis tubo stamineo adnatis; gynostegio subsessili ca. 0.45 cm. alto, antheris brevissime appendiculatis basi coronae adnatis, stigmate obscure 5-lobato ca. 0.3 cm. diam.; polliniis oblique pyriformibus valde compressis ca. 0.1 cm. longis, caudiculis multo

brevioribus, retinaculo oblongo caudiculum aequante; folliculis ignotis.—PANAMÁ: thickets near Capira, July 12, 1938, *Woodson, Allen & Seibert 1228* (Herb. Missouri Bot. Garden, TYPE); liana in thickets, Isla Taboga, July 23–24, 1938, *Woodson, Allen & Seibert 1432.*

Macroscepis panamensis differs from *M. tristis* (Seem.) Benth., the only species of the genus previously known from Panama, and apparently collected but once *(Seemann 158,*

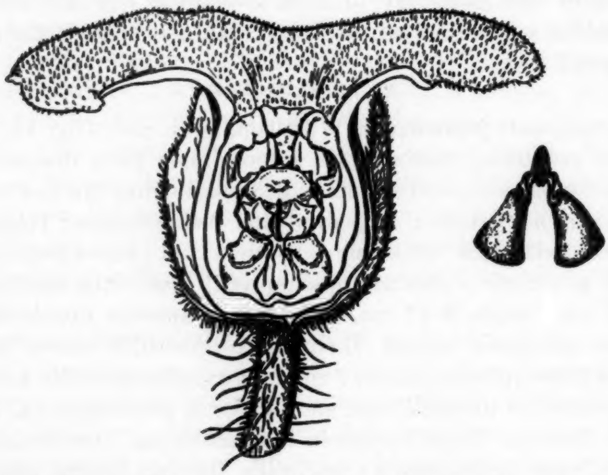


Fig. 1. *Macroscepis panamensis* Woodson. Flower in section, and pollinia. (Drawing by A. A. Heinze.)

in the Province of Veraguas near Natá), principally in the flowers. The corolla of *M. tristis* is described as absolutely glabrous, the tube light brown, and the limb dark chocolate. It is surprising that *Macroscepis* has not been collected previously in the province of Panama, as it is apparently widespread.

MARSDENIA CRASSIPES Hemsl.—PANAMÁ: thickets near Arraiján, alt. ca. 15 m., June 22, 1938, *Woodson, Allen & Seibert 779.* This is apparently the first collection of this endemic species since the discovery of the type specimen by Dr. Sutton Hayes. The corolla is greenish-yellow, and the corona seg-

ments, far surpassing the anther membranes, overhang the rostrate stigma.

MARSDENIA MACROPHYLLA (H. & B.) Fourn.—LOS SANTOS: thickets between Los Santos and Guararé, July 11, 1938, *Woodson, Allen & Seibert 1197*. As far as I am aware, this is the second time this species has been collected in Panama. I have been unable to examine the first, collected by Seemann (n. *611*) near the city of Panamá, but specimens in the herbarium of the Missouri Botanical Garden, cited as of this species by Rothe (Engl. Bot. Jahrb. **52**: 416. 1915) from Central America, have obtuse or rounded leaf bases and anther membranes slightly surpassing the crown segments (used as a key character by Rothe). On the other hand, our specimen has obviously cordate leaves, and the crown segments equal, or even slightly surpass the anther membranes.

GONOLOBUS EDULIS Hemsl.—BOCAS DEL TORO: thickets near Guabito, Aug., 1938, *J. H. Permar s.n.* Previous records of this plant have indicated its range from southern Mexico to Costa Rica. The material thoughtfully sent by Mr. Permar consists of follicles 7–8 cm. long, approximately 5 cm. in diameter, which bear conspicuous wings about 1 cm. broad.

GONOLOBUS **Monnicheanus** Woodson, spec. nov. (fig. 2). Frutex volubilis. Ramuli graciliusculi ferrugineo-pilosuli inferne glabrati. Folia opposita longiuscule petiolata, ovato-oblonga apice abrupte subcaudato-acuminata basi latiuscule cordata 4.9–9.0 cm. longa 2.5–4.5 cm. lata membranacea concoloria supra sparse ferrugine hispidulo-pilosula nervo medio basi pauciglanduligera subtus sparsiuscule ferrugineo-strigosula; petiolus 2.5–3.0 cm. longus pilosulus. Inflorescentia lateralis alternata longiuscule pedunculata umbelliformis flores mediocres dilute virido-luteos 10–30 gerens; pedunculi 3–5 cm. longi minute pilosuli; bracteae lineari-lanceolatae vix 0.2 cm. longae; pedicelli 2.5–3.5 cm. longi gracili minute pilosuli; calycis laciniae ovato-lanceolatae anguste acuminatae 0.8 cm. longae apicibus valde reflexis glabris caeterumque ferrugineo-pilosulae, squamellis alternatis solitariis dentiformibus ca. 0.15 cm. longis; corolla rotata dilute viridi-lutea extus dense

puberulo-papillata, tubo late conico ca. 0.5 cm. profundo basi ca. 0.1 cm. diam. intus dense minuteque hispidulo, lobis late ovatis obtuse acuminatis 1 cm. longis basi ca. 0.7 cm. latis apice valde reflexis; gynostegium anguste (ca. 0.2 cm.) stipitatum subalato-costatum, stigmate 5-gono ca. 0.5 cm. diam., antheris brevissime rotundeque apiculatis, polliniis compresse ovoideis ca. 0.1 cm. longis caudiculas subaequantibus, corpusculo compresse oblongo-sagittato ca. 0.025 cm. longo; corona exterior latissime campanulata 5-partita carnosa saturate lutea

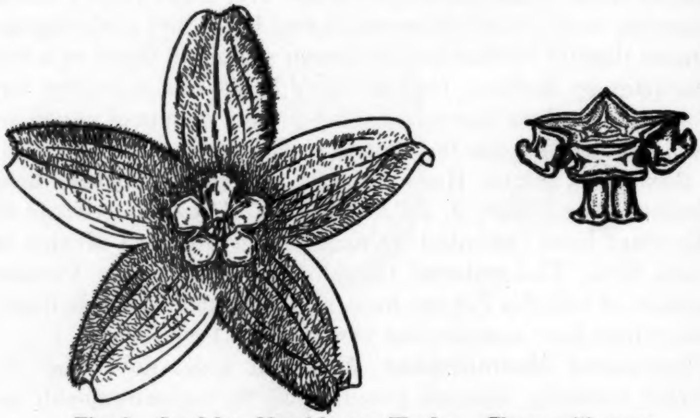


Fig. 2. *Gonolobus Monnicheanus* Woodson. Flower with gynostegium removed to show corona; gynostegium. (Drawing by A. A. Heinze.)

glabra corolla basi adnata ca. 0.7 cm. diam. ca. 0.2 cm. profunda, corona interior antheris adnata, squamis subreniformibus ca. 0.25 cm. latis 0.15 cm. longis patulis; folliculis ignotis.—CHIRIQUÍ: thickets, between Finca Lérida and Boquete, alt. 1300–1700 m., July 8–10, 1938, *Woodson, Allen & Seibert 1108* (Herb. Missouri Bot. Garden, TYPE).

This species is named in honor of Mr. Tollef B. Mönniche, the master of Finca Lérida and a discriminating and enthusiastic naturalist, in grateful memory of his innumerable kindnesses, not only to itinerant botanists, but to the multitude of other pilgrims who make their way, sure of an understanding

welcome, to his remarkable establishment on the high slopes of the Volcán de Chiriquí. *G. Monnicheanus* is evidently closely related to both *G. edulis* Hemsl. and *G. dubius* Pittier, but differs conspicuously from the former by the remarkable development of the outer corona, and from the latter in the hispidulous indument of the corolla.

CUSCUTACEAE

(T. G. Yuncker, Greencastle, Ind.)

Cuscuta **Woodsonii** Yuncker n. sp. (fig. 3). Caules crassi. Flores 4 mm. longi ab floris base ad corollae sinum, subsessiles in dispersis inflorescentibus compactis. Calycis lobi orbiculari-ovati, late imbricati, obtusi, plus minusve carinati. Corolla campanulata, lobi late ovati, obtusi, auriculati. Stamina lobis corollae dimidio breviora, antherae ovoideae, filamenta subulata, non teretia. Scalae exsertae, oblongae, fimbriatae. Styli ovarium ovoideum circa aequantes, paulo subulati. Capsula depresso-globosa, usque ad 6 mm. diametro, circumscissilia, apertura intrastylaris lata. Semina 4, circ. 2.5 mm. longa, ovalia, hilo oblongo, diagonali.

Stems coarse. Flowers membranous or somewhat fleshy, about 4 mm. in length from the base to the corolla sinuses, or 7 cm. to the apex of the corolla-lobes when erect, subsessile in scattered, few-flowered, compact clusters. Calyx rather loose about the corolla and scarcely reaching the sinuses, lobes orbicular-ovate, broadly overlapping, obtuse, fleshy in the median and basal parts, becoming thin towards the slightly uneven edges, commonly one or more lobes carinate. Corolla campanulate, lobes about as long as the tube, or slightly shorter, broadly ovate, obtuse, strongly auriculate at the base and broadly overlapping, upright to spreading. Stamens reaching to about the middle of the corolla-lobes, filaments very subulate, flattened (not terete), somewhat longer than the ovoid anthers. Scales prominent, reaching the anthers, oblong, fringed with medium-length processes about the top and sparingly so along the sides, bridged below the middle, somewhat thick and fleshy toward the attached basal part. Styles about equal to the ovoid ovary, stout and somewhat subulate.

Capsule depressed-globose, up to 6 mm. in diameter, intrastylar aperture large, becoming definitely circumscissile when mature although this character may be rather obscure in young fruit, surrounded by the withered corolla which eventually splits as the capsule enlarges. Seeds 4, about 2.5 mm. long, oval in outline, hilum oblong, oblique.—CHIRIQUÍ: vicinity of Casita Alta, Volcán de Chiriquí, alt. 1500–2000 m., June

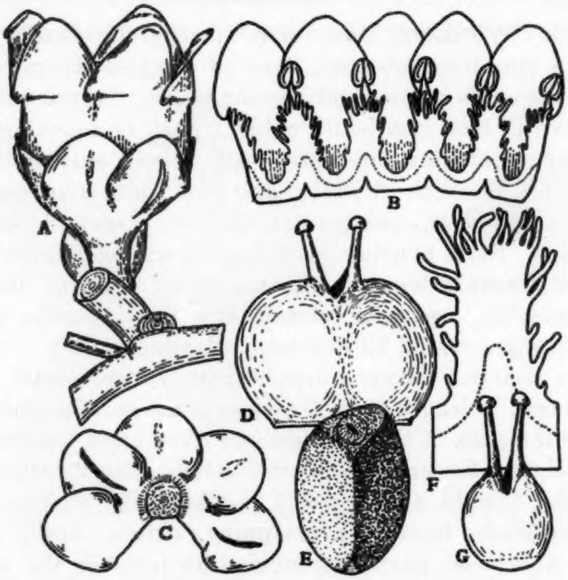


Fig. 3. *Cuscuta Woodsonii* Yuncker n. sp.: *A*, flower × 5; *B*, opened corolla × 5; *C*, opened calyx × 5; *D*, capsule × 5; *E*, seed × 10; *F*, individual scale × 10; *G*, ovary × 5.

28–July 2, 1938, on a species of *Eupatorium* (?), *Woodson, Allen & Seibert 950* (Herb. Missouri Bot. Garden, TYPE).

The genus *Cuscuta* appears to be poorly represented in Panama. The only species previously known to occur there is *C. trichostyla* Engelm. which is represented, so far as I know, by only a single specimen collected by Tweedie. *C. Woodsonii* differs from *C. trichostyla* in most of the distinctive characters given below. It appears to be most closely allied with those

included in the subsection Subulatae of the section Eugrammica although the styles do not become so strongly subulate as do those of the species included there. Its chief distinguishing features are the size of the flowers, fruit, and seeds, which are among the largest in the genus; the strongly subulate and flattened filaments; the prominent, oblong scales; and especially the prominently auriculate corolla-lobes, a character more strongly developed here than in any other known species.

BIGNONIACEAE

Arrabidaea obliqua (HBK.) Bur.—panamá: Gorgona Beach, vic. Gorgona, fr. Aug. 7, 1938, *Woodson, Allen & Seibert 1688.* Previously known from Venezuela and Colombia.

Arrabidaea Pleei DC.—coclé: between Aguadulce and Antón, alt. 15–50 m., July 12, 1938, *Woodson, Allen & Seibert 1224.* panamá: beach at Nueva Gorgona, Aug. 7, 1938, *Woodson, Allen & Seibert 1689.* Previously known from Venezuela and northern Colombia.

Lundia corymbifera (Vahl) Sandw.—chiriquí: banks of the Río Chiriquí, vic. Chiriquí, alt. 15 m., July 11, 1938, *Woodson, Allen & Seibert 1178.* Although the species has been reported from Costa Rica, and occurs frequently from Colombia to Brazil, its existence in Panama has previously been unknown.

Saldanhaea Seemanniana O. Ktze.—canal zone: Victoria Fill, near Miraflores Locks, fl. April 2, 1939, *P. H. Allen 1755.* panamá: Río de Panamá, near Capira, fl. April 4, 1938, *P. H. Allen 730;* vic. Capira, fr. July 15, 1938, *Woodson, Allen & Seibert 1310.* coclé: vic. of Penonomé, alt. 15–300 m., fl. Feb. 23–March 22, 1908, *R. S. Williams 522* (U. S. Nat. Herb. type of *Adenocalymma cocleensis* Pittier). Although previously reported from Panama by O. Kuntze, more recently the plant has been described as *Adenocalymma cocleensis,* a synonymous name.

Tabebuia heterotricha (DC.) Hemsl.—canal zone: Ancon, fl. May 1, 1934, *J. P. Keenan 323* (U. S. Nat. Herb.); vic. Summit, fl. March 17, 1934, *B. Avilla 314* (U. S. Nat. Herb.). panamá: Alhajuela, Chagres Valley, alt. 30–100 m., st. May 12–15,

1911, *H. Pittier 3501* (Gray Herb.); vic. of Chorrera, fl. March 5, 1939, *P. H. Allen 1698;* Sabanas, fl. April 1933, *Bro. Paul 307* (U. S. Nat. Herb.). Frequently confused with *Tabebuia chrysantha* (Jacq.) Nichols., but distinguishable by having a very densely woolly calyx, covered with long simple hairs and a much shorter stellate tomentum which can be seen only by the removal of the longer hairs.

The following additional specimens extend the range from Venezuela and Panama to Costa Rica and Nicaragua: COSTA RICA: without definite locality, fl. April 12, 1923, *A. M. Brenes 3876* (Herb. Field Mus.). NICARAGUA: south of Managua, fl. March 3, 1922, *J. M. Greenman & M. T. Greenman 5714* (Herb. Missouri Bot. Garden).

TABEBUIA PALMERI Rose.—PANAMÁ: vic. Bejuco, fl. Feb. 9, 1939, *P. H. Allen 1630*. Previously known to extend from the state of Michoacan in Mexico to Nicaragua.

The species flowers without leaves, making accurate determination impossible at the present time. However, flowers, pubescence and branchlets agree well with typical material of the species.

GESNERIACEAE

(C. V. Morton, Washington)

TUSSACIA **Woodsoni** Morton, sp. nov. Herba terrestris, caulibus non ramosis, apicem versus dense pilosulis; folia opposita aequalia, subsessilia, petiolo vix 5 mm. longo; lamina foliorum ovalis, usque ad 15 cm. longa et 7 cm. lata, acuta, basi longe (3–4 cm.) decurrens, tenuiter membranacea, valde crenata, supra scaberula, subtus praecipue in venis pilosula, venis primariis ca. 7-jugis; inflorescentia umbellata, ca. 4-flora, pedunculo communi axillari solitario, 2.3–2.8 cm. longo, pilosulo, apice bibracteato, bracteis linearibus, ca. 7 mm. longis, integris, pilosulis, pedicellis 12–13 mm. longis, pilosulis, apice vix incrassatis; calyx aurantiacus, ca. 15 mm. longus, campanulatus, externe scaberulo-strigillosus, tubo ca. 12 mm. longo, 10 mm. lato, lobis late triangularibus, ca. 3 mm. longis, acutis, glanduloso-denticulatis, dentibus 1 vel 2 utroque latere; corolla flava et aurantiaca, ca. 18 mm. longa, tubulosa, externe pilosa, limbo

patente, ca. 15 mm. lato.—CHIRIQUÍ: between Río Chiriquí and Remedios, alt. 15–50 m., July 11, 1938, *Woodson, Allen & Seibert 1195* (U. S. National Herb., no. 1;748,081, TYPE).

I had at first identified this collection as *Tussacia Friedrichsthaliana* Hanst., but Dr. Woodson, who had collected the latter species twice (nos. *1614* and *1642)*, told me that in the field he had considered it a distinct species, chiefly on the basis of the differently colored calyx (deep orange rather than pale yellow). With this in view I re-examined the material and have concluded that no. *1195* does in fact represent an undescribed species. All the collections of *T. Friedrichsthaliana* have the corolla glabrous, whereas no. *1195* has a distinctly pilose corolla. The different coloration of the calyx is not apparent in dried material, and requires field investigation to determine its importance. Both calyx and corolla evidently vary somewhat in color, at least according to collectors' field notes. *Woodson, Allen & Seibert* 1642 says, "calyx yellowish-green, corolla green with orange scarlet lines at base of lobes"; no. 1614 says, "corolla orange"; *Kenoyer* 536, "flowers yellow"; *Standley* 40952 and 41121, "calyx green, corolla orange"; *Seibert* 556, "flowers orange"; and *Seibert* 569, "flowers orange, streaked in corolla with reddish orange."

KOHLERIA **serrulata** Morton, sp. nov. *Moussonia.* Frutex ramosus, caulibus dense hirto-tomentosis, serius glabrescentibus, ca. 2 mm. diam., subteretibus; petioli usque ad 12 mm. longi, flavo-tomentosi; lamina foliorum ovato-lanceolata, usque ad 7.5 cm. longa et 4 cm. lata, acuminata, basi rotundata, chartacea, serrulata, supra scabro-pilosula, subtus dense pilosula, venis primariis ca. 7-jugis; flores solitarii, axillares, pauci, non pseudospicati, pedicello 15–18 mm. longo, 5 mm. supra basim bibracteato, bracteis subulatis, ca. 4 mm. longis, dense tomentosis; calycis pars adnata campanulata, ca. 2.5 mm. longa et 3 mm. lata, dense pilosa, pars libera 7 mm. longa, tubo brevissimo vix 1 mm. longo externe piloso intus glabro, lobis erectis lanceolatis 6 mm. longis et 2.2 mm. basi latis, acuminatis, apice non recurvatis, integris, margine non incrassatis, externe dense pilosis, intus sparse pilosulis; corolla aurantiaco-

rubra, 25 mm. longa, tubulosa, tubo basi non calcarato, in calyce erecto, basi 5.5 mm. lato, superne gradatim ampliato, vix ventricoso, in fauce non contracto, 9–11 mm. lato, externe dense pilosulo, intus glaberrimo, limbo brevi, lobis erectis, suborbicularibus, ca. 3 mm. longis, erosis, immaculatis; filamenta in basi corollae tubi inserta, cum tubo non adnata, inter se omnino libera, basin versus pilosa, superne glabra, non contorta, 22–25 mm. longa; antherae liberae, ca. 2 mm. longae, 1.5 mm. latae, loculis oblongis, non confluentes; ovarium (pars libera) conicum, brevissimum, dense pilosum; stylu rectus, glaber; stigma stomatomorphum; discus annularis, brevissimus, glaber, paullo undulatus.—CHIRIQUÍ: Bajo Mono, mouth of Quebrada Chiquero, along Río Caldera, alt. 1500–2000 m., July 3, 1938, *Woodson, Allen & Seibert 1609* (U. S. National Herb., no. 1,746,849, TYPE).

Perhaps related to *Kohleria elegans* (Dcne.) Loes. but distinguished by the solitary rather than umbellate flowers, the less sharply acuminate calyx-lobes, the included free anthers and glabrous style.

CAMPANEA **chiriquana** Morton, sp. nov. *Eucampanea.* Planta epiphytica, caulibus dense piloso-tomentosis, pilis brunneis multiseptatis; folia opposita paullo inaequalia, longe petiolata, petiolo usque ad 4 cm. longo, dense brunneo-tomentoso; lamina foliorum ovato-oblonga, usque ad 17 cm. longa et 9 cm. lata, apice cuspidato-acuminata, basi cuneata in petiolum decurrens, membranacea, dentata basi excepta, supra pilosula, subtus praecipue in venis dense brunneo-tomentosa, venis primariis 7- vel 8-jugis; inflorescentia umbellata triflora, pedunculo communi pendulo, valde elongato, ca. 20 cm. longo, dense brunneo-tomentoso, apice bibracteato, bracteis linearibus, ca. 9 mm. longis, dense tomentosis, pedicellis usque ad 5.5 cm. longis, dense tomentosis; calycis lobi lanceolati, 8–9 mm. longi, acuminati, non evidenter venosi, dense tomentosi; corolla pallide flava, maculata, ca. 2.5 cm. longa, tubo basi erecto, valde ventricoso, medio 1.8 cm. lato, faucem versus contracto, externe brunneo-piloso, limbo parvo, lobis rotundatis, intus glabris.—CHIRIQUÍ: vicinity of Casita Alta, Volcán de Chiri-

quí, alt. 1500–2000 m., June 28–July 2, 1938, *Woodson, Allen & Seibert 935* (U. S. National Herb., no. 1,747,001, TYPE).

Near *Campanea Oerstedii* (Klotzsch) Oersted, of Costa Rica, but with the pubescence of the stems and under-surface of the leaves more nearly tomentose (as in *C. Humboldtii*), the calyx-lobes smaller and not evidently nerved, and the corolla more prominently ventricose. The species of this genus are badly in need of a careful revision.

SOLENOPHORA **australis** Morton, sp. nov. Frutex 5 m. altus, caulibus atropurpureis obtusangulatis subquadrangulatis, glaberrimis; petiolus usque ad 4.5 cm. longus, fere glaber, apicem versus pilis sparsis flaccidis brunneis multiseptatis praeditus; lamina foliorum ovalis, usque ad 15 cm. longa et 8.5 cm. lata, acuminata, basi perspicue obliqua, rotundata, papyracea, valde biserrata, supra sparse pilosula, subtus in venis sparse scabro-pilosula, venis primariis ca. 9-jugis; flores subumbellati, pedunculo communi solitario, usque ad 4.5 cm. longo, 1.5 mm. diam., compresso, glaberrimo, ca. 3-floro, apice bibracteato, bracteis subulatis crassis ca. 1 cm. longis apice pilosulis, pedicellis ca. 1.7 cm. longis crassis glaberrimis medio bibracteolatis apice paullo incrassatis; calyx venosus, 3 cm. longus, externe fere glaber, pilis paucis minutis flaccidis multiseptatis apicem versus praeditus, intus dense pilosus, tubo subcylindrico, ca. 2.2 cm. longo, 1 cm. lato, basi late cuneato, lobis erectis ca. 8 mm. longis, triangularibus acuminatis margine glanduloso-denticulatis, dentibus 3 vel 4 utroque latere; corolla externe aurantiaca, intus flava, 8.5 cm. longa, externe parce pilosa, intus glabra, tubo 6.5 cm. longo, basi cylindrico, superne gradatim ampliato, vix ventricoso, apice 2.5 cm. lato, in fauce non contracto, limbo patente subbilabiato, lobis late obovatis vel suborbicularibus, utrinque glabris, apice subtruncatis erosis, intus marginem versus purpureo-maculatis; stamina basi corollae tubi inserta, filamentis latis glabris basi ca. 1.5 cm. connatis, antheris apice connatis, 4.5 mm. longis, 4 mm. latis, connectivo hastato glabro, loculis hippocrepiformibus, apice confluentibus, longitudinaliter dehiscentibus; stylus elongatus, compressus, ca. 2 mm. latus, valde pilosulus; stigma

latum stomatomorphum; ovarium inferum glaberrimum, placentae lamellae utrinque ovuliferae; disci glandulae 2 posticae, magnae, basi connatae, apice rotundatae, ca. 2.5 mm. longae, ubique dense pilosae.—CHIRIQUÍ: vicinity of Casita Alta, Volcán de Chiriquí, alt. 1500–2000 m., June 28–July 2, 1938, *Woodson, Allen & Seibert 847* (U. S. National Herb., no. 1,746,987, TYPE).

Closely related to *Solenophora calycosa* Donn. Smith, of Costa Rica, but distinguished by the entirely glabrous ovary, nearly glabrous calyx-tube, and glabrous stems and peduncles.

COLUMNEA TOMENTULOSA Morton—BOCAS DEL TORO: Río Cricamola, between Finca St. Louis and Konkintoë, alt. 10–50 m., Aug. 12, 1938, *Woodson, Allen & Seibert 1876*. Previously known from Nicaragua and Costa Rica.

COLUMNEA **panamensis** Morton, sp. nov. *Eucolumnea*. Frutex epiphyticus parce ramosus, caule subtereti parce strigoso ca. 8 mm. diam., ramulis brevibus, dense antrorse strigosis; folia opposita aequalia, breviter petiolata, petiolo ca. 4 mm. longo, strigoso-hirtello; lamina foliorum elliptica vel anguste elliptica, 4–4.5 cm. longa et 1.5–1.9 cm. lata, vix acuta, basi cuneata, chartacea, integra, utrinque dense strigoso-pilosa, immaculata, venis primariis 4-jugis; flores adscendentes solitarii axillares, pedicello 1.5 cm. longo, dense albido-tomentoso; calycis lobi liberi, lineari-oblongi, ca. 1.5 cm. longi, 4 mm. lati, acuti, basi angustati, integri, utrinque pilosi; corolla coccinea, 6.5–7 cm. longa, in calyce suberecta, basi postice gibbosa, tubo ca. 3 cm. longo, basi ca. 4 mm. lato, sursum ampliato sed non ventricoso, in fauce 10–11 mm. lato, non contracto, externe piloso, limbo valde bilabiato, galea erecta integra, 3–3.5 cm. longa, apicem versus ca. 1.4 cm. lata, lobis lateralibus cum galea alte connatis (1.8–2 cm.), partibus liberis deltoideis acutis, inferiore patente, lineari-oblongo, 1.5–1.7 cm. longo; filamenta pilosula, apice recurvata; antherae quadratim connatae, mox liberae, 2.6 mm. longae, 2.4 mm. latae, glabrae, loculis oblongis; ovarium dense albo-villosum; stylus elongatus pilosulus; stigma stomatomorphum; disci glandula crassa emarginata, ca. 2.3 mm. longa et 2.2 mm. lata, glabra.—CHIRIQUÍ:

vicinity of Casita Alta, Volcán de Chiriquí, alt. 1500–2000 m., June 28–July 2, 1938, *Woodson, Allen & Seibert 860* (Herb. Missouri Bot. Garden, TYPE).

Perhaps allied to *C. microcalyx* Hanst., of Costa Rica, but distinguished by the larger, longer-petiolate leaves, the different pubescence of the leaves, pedicels and calyx lobes, more deeply cleft corolla, and especially by the puberulous filaments.

RUBIACEAE

(P. C. Standley, Chicago)

RUDGEA **isthmensis** Standl., sp. nov. Arbuscula 4-metralis ut videtur omnino glabra (flores non visi), ramis gracilibus viridibus teretibus, internodiis valde elongatis; stipulae deciduae, non visae, basi intus setis numerosis incrassatis corneis pallidis ca. 2 mm. longis persistentibus auctae; folia mediocria breviter petiolata chartacea, petiolo crassiusculo 8–11 mm. longo; lamina ovata vel oblongo-ovata 12–14 cm. longa 5–7.5 cm. lata anguste longiacuminata, basi obtusa vel rotundata atque breviter contracta, supra opaca viridis, nervis venisque prominulis, subtus fere concolor subflavescens, costa elevata, nervis lateralibus utroque latere ca. 8 prominentibus angulo latiusculo adscendentibus subarcuatis remote a margine conjunctis, venulis prominulis laxe reticulatis, axillis nervorum lateralium poro magno domatiatis; inflorescentia terminalis parva cymoso-paniculata ca. 2.5 cm. longa et 3 cm. lata pauciflora 18 mm. longe pedunculata, ramis primariis basi non bracteatis, infimis divaricatis rigidis, floribus sessilibus; fructus late ovalis 1 cm. longus 8 mm. latus, pyrenis dorso grosse obtuse costatis.—CANAL ZONE: vicinity of Salamanca Hydrographic Station, Río Pequení, alt. 80 m., July 28–29, 1938, *Woodson, Allen & Seibert 1618* (Herb. Field Mus., TYPE; duplicate in Herb. Missouri Bot. Garden).

The only other species of *Rudgea* previously known from the region, *R. cornifolia* (Humb. & Bonpl.) Standl. *(R. fimbriata* Standl.) has practically sessile leaves. In *R. isthmensis* the remains of the calyx persistent upon the fruit show that the calyx is barely 0.5 mm. in height and remotely denticulate.

CAPRIFOLIACEAE

Viburnum stellato-tomentosum (Oerst.) Hemsl.—chiriquí: thickets between Finca Lérida and Boquete, ca. 1300–1700 m., July 8–10, 1938, *Woodson, Allen & Seibert 1103.* This species, apparently rather frequent in Costa Rica, has previously been unrecorded from Panama.

CUCURBITACEAE

Cucurbitacea sp. We have been unable to place this specimen either to genus or to species. Our material consists of a rather slender, scandent herb; stems essentially glabrous; leaves ovate, broadly cordate, acutely acuminate, 12–13 cm. long, 10–11 cm. broad, membranaceous, minutely and sparsely bullate, otherwise glabrous, the petioles very slender, 4 cm. long, glabrous; tendrils opposite the leaves; staminate inflorescences spicate-paniculate, in some cases with as many as 6 slender branches 15–30 cm. long, bearing occasional reduced tendrils interspersed amongst the distant, nearly sessile floral clusters; staminate flowers greenish-yellow, pedicel 1 mm. long; calyx-lobes 5, equal, broadly ovate, 2.5 mm. long; corolla a fleshy, entire, disc-like ring 0.5 mm. deep, adnate to the base of the calyx; staminal column slender, 1 mm. long, anthers sessile, 5, sigmoid. Since pistillate flowers and fruit are lacking, it is scarcely possible to refer the material to either a new or a pre-existing genus.—bocas del toro: vicinity of Nievecita, alt. ca. 0–50 m., Aug. 8–19, 1938, *Woodson, Allen & Seibert 1841* (unicate, in Herb. Missouri Bot. Garden).

COMPOSITAE

(S. F. Blake, Washington; Senecio by J. M. Greenman, St. Louis)

Senecio Cooperi Greenm.—chiriquí: Bajo Mona, mouth of Quebrada Chiquero, along Río Caldera, alt. 1500–2000 m., July 3, 1938, *Woodson, Allen & Seibert 1014.* Previously known only from the highlands of Costa Rica.

Lagenophora **panamensis** Blake, sp. nov. (pl. 23). Herba perennis pumila pluricaulis; caules adscendentes ca. 1 dm. alti sparsissime pubescentes usque ad capitula foliosi; folia basalia spathulata v. oblanceolata ca. 5 cm. longa obtusa penni-

nervia subcoriacea, lamina crenato-serrata breviter ciliata caeterum subglabra in petiolum subaequalem late marginatum sparse ciliatum angustata; folia caulina ca. 9–14 internodiis saepius longiora, inferiora basalibus similia sed breviora, media et superiora linearia sessilia sparse ciliata prope apicem crenato-serrata, suprema integra; capitula 2–3 parva radiata terminalia et in axillis supremis, pedunculis dense adscendenti-pilosulis quam foliis subtendentibus brevioribus; involucri ca. 4 mm. alti 3-seriati paullum gradati appressi, phyllaria lineari-oblonga obtusa tenuiter subherbacea angustissime subscarioso-marginata 1-nervia infra ciliata supra ciliolata; radii numerosi patentes parvi lavendulacei; corollae disci flavae (?); achenia radii obovata margine crasse nervata breviter rostrata, rostro dense sessili-glanduloso; achenia disci similia, rostro brevissimo annulari; pappus nullus.

Plant apparently cespitose; rootstock oblique, about 4 mm. thick; stems several, greenish, subterete, few-ribbed, essentially glabrous below, above sparsely puberulous and with scattered long hairs, leafy throughout; basal leaves few, about 5 cm. long including petiole, the blade 2–2.8 cm. long, 10–12 mm. wide, crenate-serrate throughout (teeth 5–8 pairs, rather crowded, 1–3 mm. long, obtusely callous-pointed at the rounded apex, occasionally 1-toothed on the side), short-pilose-ciliate, narrowed into the petiole, this sparsely pilose-ciliate with longer hairs especially toward base; middle stem leaves 1.5–2.5 cm. long, 3–5 mm. wide, sparsely pilose-ciliate with many-celled hairs, toward apex crenate-serrate or serrate with 1–4 pairs of obtuse or acute teeth; peduncles about 5 mm. long; heads (moistened) 12.5 mm. wide; disk (moistened) about 8 mm. wide, 4 mm. high; involucre flattish-hemispheric, about 9 mm. wide, 4 mm. high, the phyllaries 0.6–0.8 mm. wide, sometimes purplish-tinged above, sparsely pilose-ciliate toward base, more densely ciliolate toward tip with sometimes subglandular hairs, otherwise glabrous; disk flattish, naked; rays about 57, spreading, 2-seriate, fertile, "pale pink-lavender," glabrous, the tube 0.3 mm. long, the lamina narrowly oblong or linear-elliptic, 2-dentate or 3-denticulate, 2–3-nerved, 2.6–2.8

mm. long, 0.6–1 mm. wide; disk flowers about 28, apparently mostly sterile but some perhaps fertile, their corollas glabrous, 2.2–2.5 mm. long (tube 0.6–0.8 mm., throat campanulate, 0.7–0.9 mm., teeth 5, ovate, acute, spreading, 0.8 mm. long); ray achenes (immature) obovate, compressed, thick-nerved on the margin, nerveless on sides, 2.2 mm. long including beak, abruptly or gradually narrowed into a short thick densely sessile-glandular neck 0.4 mm. long, otherwise glabrous, epappose; disk achenes (immature) obovate, compressed, thick-nerved on margin, nerveless on the sides, 2 mm. long, 0.7–0.8 mm. wide, slightly narrowed at apex and then slightly expanded into a ring-like usually densely sessile-glandular neck about 0.1 mm. high; style branches of hermaphrodite flowers lance-oblong, acute, hispidulous throughout dorsally, without stigmatic lines.—CHIRIQUÍ: on potrero, Loma Larga to summit, Volcán de Chiriquí, alt. 2500–3380 m., July 4–6, 1938, *Woodson, Allen & Seibert 1047* (U. S. National Herb., no. 1,746,842, TYPE).

The discovery of a species of *Lagenophora* on the highest mountain in Panama is of considerable phytogeographic interest. *Lagenophora,* a genus of Astereae containing about twenty-three species, has its center of distribution in the Australian region. Seven species are found in New Zealand and outlying islands, and four others in Australia, one of which occurs also in Ceylon, eastern India, Hongkong, Java, Sumatra, and the Philippines. Three species have been described from the Hawaiian Islands, two from the Liukiu Islands, and one each from Borneo, New Caledonia, and the Fiji Islands. The half dozen proposed species from South America reduce to three, *L. harioti* Franch., *L. hirsuta* Less., and *L. nudicaulis* (Lam.) Dusén *(L. commersonii* Cass.), which range from central Chile (Rancagua) to Tierra del Fuego, one of them occurring also on Tristan da Cunha. *L. purpurascens* Phil. is reduced to *L. nudicaulis* by Reiche, and *L. lechleri* and *L. muscicola,* both *nomina nuda* made by Schultz Bipontinus, are equivalent to *Laestadia lechleri* and *L. muscicola* of Weddell.

The three South American species are all scapose or essen-

tially so and quite different in appearance from *L. panamensis.* Of the some fourteen species available for comparison, the Hawaiian *L. mauiensis* Mann is most similar in appearance to *L. panamensis,* but the former is readily distinguished by its serrate rather than crenate leaves, its glandular-pubescent stem, and its much larger solitary heads.

Sabazia triangularis var. **papposa** Blake, var. nov. Achenia radii glabra epapposa vel interdum squamellam unicam oblongam fimbriatam 0.6 mm. longam angulo interno gerentia; achenia disci erecto-hirsutula papposa; pappi squamellae 5–6 1-seriatae oblongae obtusae fimbriatae 0.8 mm. longae tubam corollae aequantes.—chiriquí: Loma Larga to summit, Volcán de Chiriquí, alt. 2500–3380 m., July 4–6, 1938, *Woodson, Allen & Seibert 1055* (U. S. National Herb., no. 1,746,843, type).

In the type of *Sabazia triangularis* Blake *(Pittier 3109,* El Potrero Camp, Volcán de Chiriquí, alt. 2800–3000 m.) the ray achenes are glabrous and epappose, the disk achenes hispidulous and likewise epappose. The differences between the typical form and the variety are much like those separating *Sabazia pinetorum* Blake and its var. *dispar.*

Piqueria trinervia Cav. var. luxurians Kuntze—chiriquí: Loma Larga to summit, Volcán de Chiriquí, alt. 2500–3380 m., July 4–6, 1938, *Woodson, Allen & Seibert 1044.* Apparently the first record for any form of the genus in Panama. The variety was previously known from Costa Rica; the typical form ranges from Mexico to Costa Rica, and is also recorded by Robinson from Haiti.

Explanation of Plate

PLATE 20

Vriesia Woodsoniana **L. B. Smith**

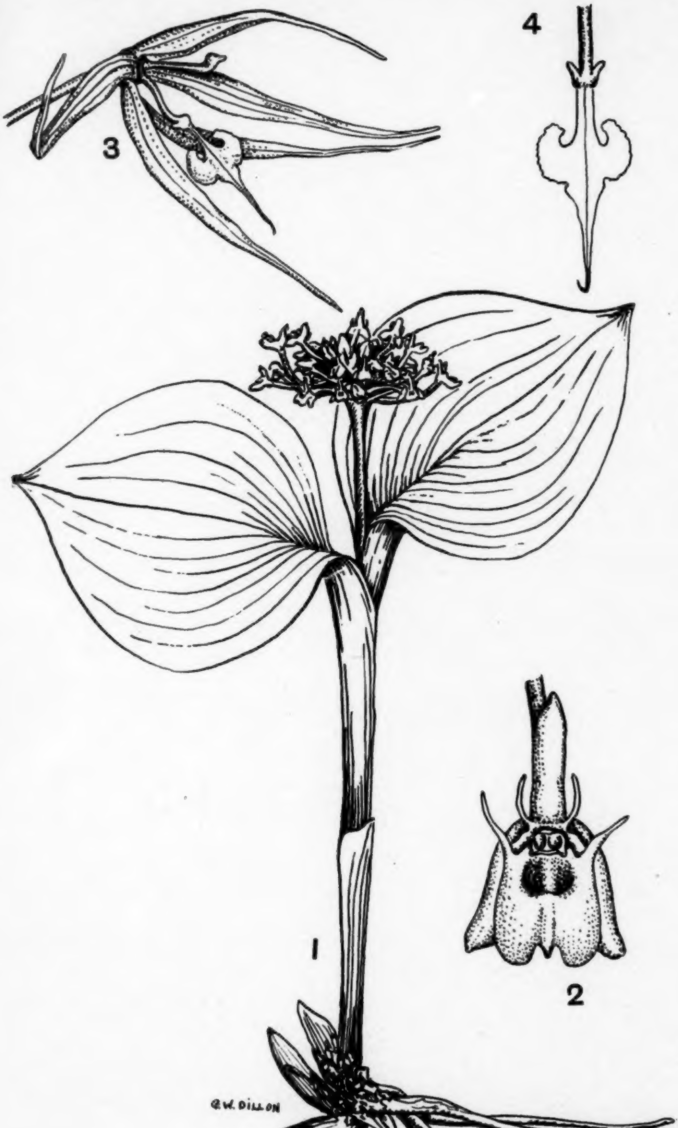
WOODSON AND SEIBERT—FLORA OF PANAMA

EXPLANATION OF PLATE

PLATE 21

1. *Malaxis Woodsonii.* Plant natural size.
2. *Malaxis Woodsonii.* Flower × 5.
3. *Notylia Cordesii.* Flower × 4.
4. *Notylia Cordesii.* Labellum × 8.

(Figures drawn from the types by G. W. Dillon.)



WOODSON AND SEIBERT—FLORA OF PANAMA

Explanation of Plate

PLATE 22

Maytenus Woodsoni Lundell. From type specimen, *Woodson, Allen and Seibert 1065,* in Herbarium of the University of Michigan. × ½.

WOODSON AND SEIBERT—FLORA OF PANAMA

Explanation of Plate

PLATE 23

Lagenophora panamensis Blake (natural size).

WOODSON AND SEIBERT—FLORA OF PANAMA

THE GENETIC COEFFICIENTS OF SPECIFIC DIFFERENCE

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For the precise study of evolution of populations, races, or species, nearly every problem sooner or later requires some measurement of the morphological divergencies in the groups under observation. This is equally true and the problem is fundamentally the same whether one be studying very closely related species of *Drosophila* (Dobzhansky and Mather, '39), varieties of gall wasps (Kinsey, unpublished), fields of irises (Anderson, '36a), or the races of man (Pearson, '26, and various other authors). It is usually taken for granted in such studies that any measurable feature or features of the organism will serve equally well as a measure of likeness if only the records be made with care and treated with the precise methods of biometry. Improvements have recently been made by considering differences in groups of measurements, the data being combined crudely (Anderson, '36a, '36b, Anderson and Hubricht, '38) or by refined biometrical techniques (Fisher, '36b).

These methods are all based on the tacit assumption that species differences are expressed more or less at random. A study of such differences has convinced us that their morphological nature renders these methods relatively inefficient. Species do not differ in a random manner. They differ in a peculiar and subtle way. If any two closely related species of the flowering plants are examined critically it will be found that they differ as a whole by two sets of harmonically integrated tendencies (Anderson and Whitaker, '34). Such a conclusion, however, is of little use in quantitative work. In section I, therefore, there is developed a precise mathematical

expression for the difference between "two sets of harmonically integrated tendencies." The application of this formula is illustrated in section II, where an attempt is made to analyze the differences between *Nicotiana alata* and *N. Langsdorffii* and to show how, from an estimate of their "genetic co-efficients," an efficient measure of their total difference could be developed.

I. A GENERAL FORMULA FOR THE EFFICIENT MEASUREMENT OF SPECIFIC DIFFERENCES

It might seem impossible to formulate any mathematical definition of species differences broad enough to apply to organisms as different as flowering plants, insects, and vertebrates. A little reflection, however, will remind one that the gene-chromosome-cell relation is fundamentally the same in these various organisms and that species differences, in so far as they rest on the gene-chromosome-cell system, may be expected to exhibit certain general features.

Closely related species or races may be conceived as made up of a large number of characters, the number considered in any particular instance depending upon the viewpoint of the observer. Any two closely related species, however, will have the same sets of characters which differ only in their proportionate development. In studying races of mankind, for instance, there might be considered the head, the neck, the trunk, the arms, and the legs of the two races. If the set of characters were subdivided into such categories as fingers, ears, etc., it would still be possible to observe the same set in both races.

We may therefore define the gross morphology of any organism as being the sum of a set of characters: Organism = A + B + C + D + E + F + ... + N. In so far as species differences rest in the germ-plasm, the basic differences between the two species will not be differences in these characters but in the germ-plasm which give rise to them, and they can be thought of as made up of a set of differences between corresponding factors of the germ-plasm. These factors in the germ-plasm we shall write a, b, c, d, e, ... n for one species, and a′, b′, c′, d′, e′, ... n′ for the other. Some of these may relate to proc-

esses so general that they are expressed in every character (as, for instance, a gene affecting cell division or wall formation). For such factors we shall use the first letters of the alphabet and we may write the first species as: (abc ......)A + (abc ......)B + (abc ......)C + (abc ......)D + ... + (abc ......)N, while the second species will be written: (a′b′c′ ......)A + (a′b′c′ ......)B + (a′b′c′ ......)C + (a′b′c′ ......)D + ... + (a′b′c′ ......)N. The dots within the parentheses represent additional factors affecting all the characters. Other factors will affect only similar characters, as, for instance, the leaf and the calyx in flowering plants, or hand and foot in vertebrates. For them we may use the middle letters of the alphabet. There are probably also elements in the germplasm which affect only single characters. If we use letters at the end of the alphabet for them, then the total morphological difference between two related species is described by the following mathematical expression:

(abc ... m .. x ..)A + (abc ... m .. y ..)B + (abc ... n .. z ..)C + ... + (abc ... p .. w ..)N – (a′b′c′ ... m′ .. x′ ..)A + (a′b′c′ ... m′ .. y′ ..)B + (a′b′c′ ... n′ .. z′)C + ... + (a′b′c′ ... p′ .. w′ ..)N.

From this it follows that a set of observations upon A or upon A and B will probably be an inefficient way of getting at fundamental differences between the two species. That is to say, instead of comparing two races of men by their skulls alone, or two species of *Acer* by their leaves, we should first attempt to determine the most efficient way of measuring the coefficients which affect skull, trunk, and appendages in man, or leaf, stem, and inflorescence in *Acer*. What is needed is the most efficient way of measuring (a – a′), (b – b′), (c – c′), ... (n – n′). These genetic coefficients of specific difference (a vs. a′, b vs. b′, c vs. c′, etc.) cannot be determined from casual inspection. While their determination is a much more simple matter in the flowering plants than in the insects or vertebrates, it will even there require detailed observation and experiment. How to measure any particular specific difference is a research problem which should be undertaken before one proceeds to the actual measurement.

II. AN ESTIMATE OF THE GENETIC COEFFICIENTS WHICH DIFFERENTIATE *NICOTIANA ALATA* FROM *N. LANGSDORFFII*

The species chosen for comparison were *Nicotiana alata* and *N. Langsdorffii.* They were selected because (1) they are easily grown for observation and experiment, (2) a large body of genetic and cytological data is already at hand concerning their behavior in crosses and back-crosses (East, '16, Sachs-Skalinska, '21, Brieger, '35, Smith, '37, Avery, '38, Anderson, '39), (3) an estimate of their genetic coefficients was desired as the basis for analysis in further crosses. *Nicotiana alata* is the night-blooming species with large white flowers, known to gardeners as *N. affinis. N. Langsdorffii* is a smaller, chunkier species, with bright green flowers and blue pollen. Representative flowers of each are illustrated in plate 24, A–C. Seed of *N. alata* was obtained from the Palmer Seed Company of St. Louis. Some of the plants bore pale pink corollas, probably the result of hybridization in cultivation with X *Nicotiana Sanderae (= N. alata X N. Forgetiana).* The strain of *N. Langsdorffii* was kindly supplied by Dr. H. H. Smith of the U. S. Department of Agriculture. The known facts of the relationship and distribution of the two species have been summarized by Avery ('38). The points which concern us here are that both species are diploid members of the 9-chromosome group of *Nicotiana,* and that they are both native (or are at least widely distributed) in a large region in central South America. From a study of the meiotic configurations of their hybrids Avery concluded that the gross differences in their chromosome complements were confined to two translocations in three pairs of chromosomes. Like some of the evidence submitted below, this fact supports (though it does not prove) Anastasia's speculation ('14) that *N. Langsdorffii* may be the result of a cross between *N. alata* or a closely related species and some such member of the 24-chromosome group as *N. rustica,* by which a few segments of *rustica* germ-plasm became incorporated in an *alata* genom (Avery, '38). If this is indeed the relationship between *N. alata* and *N. Langsdorffii,* the case, while exceptional, is not unique in our opinion. There

are a number of genera of flowering plants in which the morphological resemblances between the species would indicate similar relationships.

1. Cell size.—In searching for the fundamental genetic coefficients which differentiate these two species, one of the most obvious places to look is the cell itself. If there are outstanding differences in cell size, cell uniformity, or in the development of the cell wall, they should be comparatively easy to detect. An inherent cell-size difference, for instance, should manifest itself in a consistently larger size of one species, even in those organs in which there are no obvious differences in proportion. Even a superficial examination will show that

Fig. 1. A, corolla-tube of *Nicotiana alata* (above) and of *N. Langsdorffii* (below); B, corolla-throat of *N. alata* (above) and of *N. Langsdorffii* (below). All figures drawn to the same scale.

Nicotiana alata is generally larger throughout than is *N. Langsdorffii*. The shape differences in the corolla are confined to the base of the tube and the limb. The throat of the corolla, although complex in shape, is of practically the same proportion in the two species, and is roughly half again to twice as large in *N. alata* as in *N. Langsdorffii* (pl. 24, and fig. 1, B). The pedicels, the cross-section of the style, the capsule, and the seeds show the same relationship. Histological examination shows that the surmise of a fundamental difference in cell size is probably correct. While measurements of whole tissues were not undertaken, examinations were made in all those organs which seemed to have about the same proportions. Camera-lucida drawings are presented in fig. 2. It will be noted that, in each, the cells of *N. alata* are larger than those of *N. Langsdorffii* and that in each the ratio of their diameters

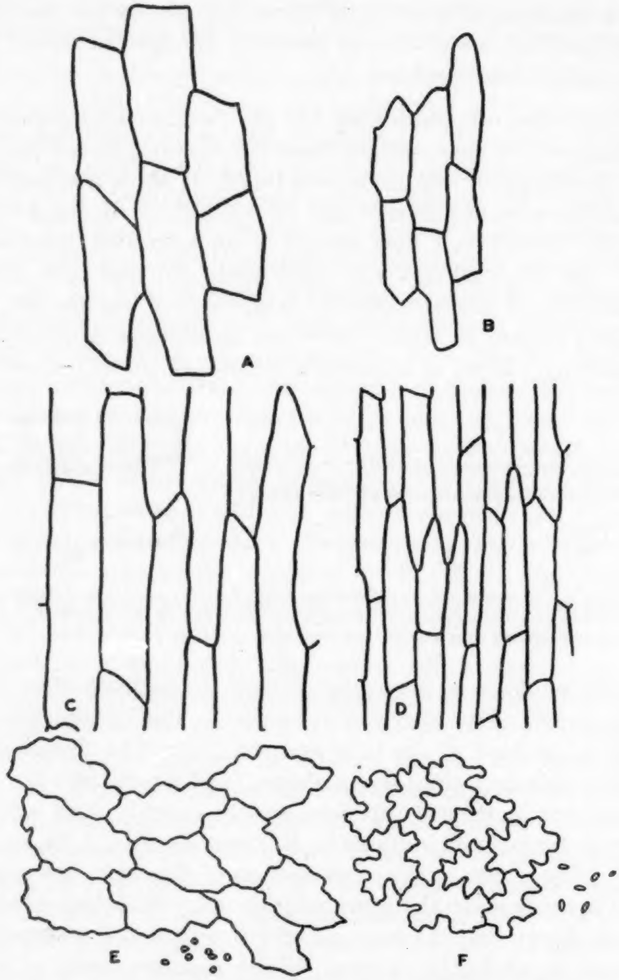

Fig. 2. Histological details to show relative size of cells in *Nicotiana alata* and *N. Langsdorffii:* epidermal cells from base of corolla-tube, (A) in *N. alata,* (B) in *N. Langsdorffii;* epidermal cells from corolla-throat, (C) in *N. alata,* (D) in *N. Langsdorffii;* ten epidermal cells from corolla-limb, (E) in *N. alata,* (F) in *N. Langsdorffii.* The plastids drawn in E and F show relative size, but not relative number or distribution.

is roughly from 1:1.5 to 1:2. Furthermore, this ratio agrees with the size differences of the organs concerned. Note particularly the pedicels, the corolla-throats, the pollen, and the seeds (fig. 3 and pl. 24).

As a working hypothesis we may therefore conclude that one of the fundamental differences between *N. alata* and *N. Langsdorffii* is cell size, and that it is apparently expressed throughout the organism. Its expression is certainly modified by localized differences in cell elongation, as will be shown below, and perhaps by differences in cell number, though we have as yet little definite information on that point.

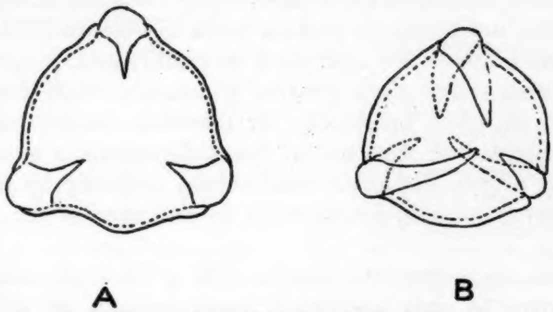

Fig. 3. Pollen grains of (A) *Nicotiana alata*, and (B) *N. Langsdorffii*.

2. *Cell elongation.*—The most striking difference in flower shape between the two species is the constricted portion of the corolla-tube below the point where the stamens are inserted. In *Nicotiana Langsdorffii* this is so short that it cannot be seen without removing the calyx. In *N. alata* it is much longer than the throat (pl. 24, A, C, and fig. 1, A). Histological examination showed that the difference is mainly due to cell elongation. Allowing for the basic difference in cell size (see above) the cells of the tube in *N. alata* are proportionately no wider than those in *N. Langsdorffii* though they are many times as long (Nagel, '39). It seemed probable that such a difference should be expressed elsewhere throughout the plant, and even a cursory examination showed this to be the case. *Nicotiana alata* is not only a somewhat larger plant

than *N. Langsdorffii;* it has a general tendency to be somewhat more elongated. It has narrower leaves (largely due to more elongated petioles), longer internodes, narrower bracts, longer calyx-lobes, a much longer style, and a more pointed ovary, resulting in elongate lobes of the ripened capsule (pl. 24, D, E). It seemed probable that all of these correlated differences rest on a difference in the mechanism of cell elongation. This point has very kindly been investigated by Miss Nagel, whose results are reported in the accompanying paper. She finds that there is a basic difference in the auxin response of the two species. *Nicotiana Langsdorffii* apparently inactivates auxin very readily and therefore shows little or no response even when it is supplied artificially in various ways. *Nicotiana alata,* on the other hand, does not inactivate it so readily and, in stem, leaf, and flower, shows even greater elongation when additional auxin is supplied artificially. It therefore seems quite definitely established that one of the differentiating genetic coefficients affects the auxin mechanism, probably by bringing about greater auxin inactivation in one species than in the other.

It seems quite probable that several of the coefficients listed below may be only accessory manifestations of this same auxin difference. This is particularly true of number 3, geotropic response, and number 4, leaf-vein angles.

3. Geotropic orientation of appendages.—Appendages of the axis, and its own branches, diverge at a more acute angle in *Nicotiana alata* than in *N. Langsdorffii.* This angle divergence is roughly the same in leaves, pedicels, bracts, and branches of the inflorescence (fig. 4). It has been well established that the geotropic response of flowering plants is accomplished through auxin regulation (Dolk, '36). Whether or not the difference in appendage orientation is due to the same auxin-mechanism difference as that affecting corolla-tube elongation we have as yet no means of proving.

4. Leaf-vein angles.—The angles made by the side-veins with the midrib of the leaf are also more acute in *N. alata* than

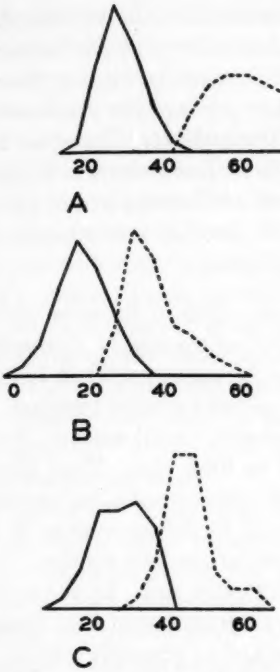

Fig. 4. Frequency distributions showing angle of divergence of (A) leaf, (B) flowering pedicel, and (C) branch of the inflorescence. The solid line, in each case, represents *Nicotiana alata*, the broken line, *N. Langsdorffii*. The numbers along the base lines represent the angles of divergence, in degrees.

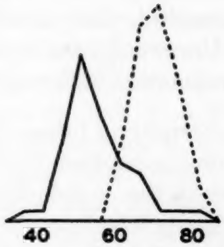

Fig. 5. Frequency distributions showing angle of divergence of the secondary vein near the base of the leaf blade, in *Nicotiana alata* (solid line) and *N. Langsdorffii* (broken line). The numbers represent the angles, in degrees.

in *N. Langsdorffii* (fig. 5). While it is probable that this difference is related to auxin concentrations, further experimentation will be required to discover its relation to geotropism and elongation in the appendages.

5. *Plastid color*.—The most conspicuous difference between the two species is the color of the flowers. The corollas of *N. alata* are a clear ivory-white within, somewhat tinged with green on the outside. Those of *N. Langsdorffii* are bright green

on both sides. Microscopical examination shows this difference to reside in the plastids, which are ivory in the former and green in the latter. While this difference is most extreme in the flower it is also expressed in other parts of the plant, notably in the midribs of the leaves and in the pedicels. These are ivory at maturity in *N. alata* and green in *N. Langsdorffii*. We therefore conclude that one of the genetic coefficients which differentiate the two species is the ability to develop ivory rather than green plastids under certain conditions.

6. *Peripheral foliar development.*—One of the most striking differences between the flowers of *N. alata* and *N. Langsdorffii* occurs in the corolla-limb. In the former species it is larger and deeply lobed; in the latter, small and almost unlobed. The difference in cell size, discussed above, would account for not more than half of the difference in limb size. That there is evidently a genetic coefficient in *N. alata* producing continued development of the marginal tissue in foliar organs is suggested by a comparison of the leaves of the two species. Those of *N. Langsdorffii* are characteristically flat. In those of *N. alata* the margin has developed to such an extent that it cannot be accommodated in a flat position and is strongly waved. We therefore suggest that one of the differentiating genetic coefficients we are seeking affects the development of the margin in leaf and corolla.

7. *Basal foliar development.* A further conspicuous difference between the species is in the shape of the corolla limb, which is deeply lobed in *N. alata* and so slightly lobed in *N. Langsdorffii* that the limb sometimes has a slightly greater diameter at the sinuses than at the apex (which can still be recognized, however, by the veining pattern). Part of this difference in shape is a physiological necessity of the greater size and is not due to specific shape differences. It has already been shown (Anderson, '39) that in the genicly uniform F_1 between the two species there is a correlation of .3105 ± .1077 between the degree of lobing and the limb width. An examination of the limb offers a simple explanation of this correlation.

The main vein is down the center of the lobe, and it might be expected that with increased growth of the limb there must of necessity be a greater increase proportionately at those points near the food supply (the tips of the lobes) than at those points which are remote from the food supply (the sinuses). There is evidence, however, that there are factors in *Nicotiana alata* making for accentuated lobes other than those concomitant with the increase in size. The F_2 correlations between lobing and limb width are much greater (.7186 ± .0300) than those of the F_1, indicating a genetic correlation as well as a purely physiological one. Furthermore, second-generation hybrids with limbs of the same size differ among themselves in the amount of lobing of the corolla. *Nicotiana alata* therefore differs from *N. Langsdorffii* not only in the size of its limb but in a tendency for the limb to grow more towards the tip and less towards the base.

It seems not impossible that this same tendency may also operate in the other foliar organs. The leaves of the two species differ in length of the petiolar portion (as has been discussed above) and in shape of the basal portion of the blade, which is proportionately wider in *N. Langsdorffii.* If two leaf blades of about the same size and age are selected and laid side by side it will be seen that their tips are very similar and that most of the difference in blade shape is due to the wider base. The leaf of *N. Langsdorffii* is furthermore more decurrent on the stem than is that of *N. alata.* As a basis for further experiment we would therefore suggest that one of the genetic coefficients distinguishing the two species is a factor for greater basal development in foliar organs. Its chief effect in *N. Langsdorffii* is to make the blade proportionately broader at the base and, by exerting a similar effect upon corolla-lobes, to lessen the lobing of the corolla. The evidence for such a coefficient is much more speculative than that for the coefficients previously discussed.

8. *Pollen color.*—The pollen of *N. Langsdorffii* is bright blue, that of *N. alata* is ivory-colored. Smith has shown ('37) that the production of blue pollen is due to two complementary

genes which are independent of the gene for green plastid color.

9. Time of blooming.—The flowers of *N. alata* begin to open late in the afternoon and close, as if wilted, during most of the day. While we have made no precise experiments, this is apparently correlated with both light and temperature. On a dark day, or indoors, the flowers of *N. alata* may remain more or less expanded throughout the day. *Nicotiana Langsdorffii*, on the other hand, is a day-blooming species, though it wilts in strong sunshine even more readily than other day-blooming Nicotianas. It seems possible that this difference between the species may be another expression of the plastid difference discussed above. If this be true, it should be possible to establish the fact by a careful study of second-generation and back-cross individuals.

10. Scent.—The flowers of *N. alata* are delightfully scented, particularly when they first expand in the early evening. Those of *N. Langsdorffii* have little or no odor.

11. Inflorescence.—Typical inflorescences of each species are diagrammed in fig. 6. They exhibit at least two kinds of difference between the two species: degree of branching, and determinate vs. indeterminate nodes. *Nicotiana Langsdorffii* shows a much higher degree of branching than does *N. alata*. It is difficult to score definitely because in both species the amount of branching is affected by the food supply. Starved in a two-inch pot even *N. Langsdorffii* will have a simple stem. When grown in four- or five-inch pots, however, it always shows numerous well-developed secondary axes and at least a few of the third and fourth order. *Nicotiana alata* often shows only a few secondary and no tertiary axes.

Nicotiana alata is apparently indeterminate, but there is no transparent relation between flowers and bracts. In *N. Langsdorffii* every axis, whether primary, secondary, or of a higher order, is terminated by a flower. The terminal flower on the primary axis is the first to bloom, followed by those terminating the two upper secondary axes. These facts would indicate that the inflorescence is in part truly determinate. On

the other hand, these terminal flowers are not subtended by bracts, but small bracts, usually without flowers, occur a short way up each of the secondary axes. This might indicate that the terminal flowers are falsely determinate. Whether the de-

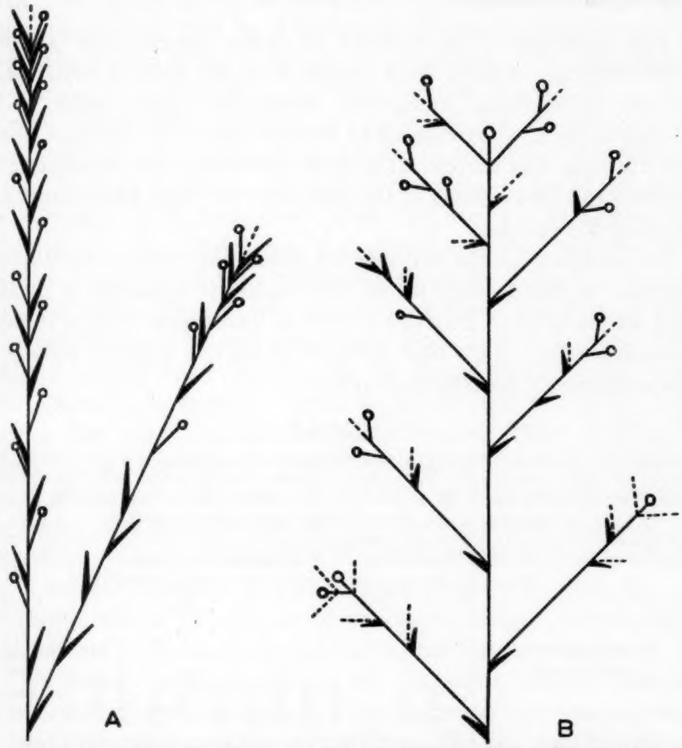

Fig. 6. Inflorescence diagrams of (A) *Nicotiana alata*, and (B) *N. Langsdorffii*. The angles of divergence of leaves, pedicels, and branches are average ones for the two species. No attempt is made to show relative length of internodes, leaves, or pedicels. Broken lines indicate continuation of the axes.

terminateness of *N. Langsdorffii* is affected by coefficients which are expressed elsewhere in the organism cannot be ascertained without further experiment. From what is known about such matters it would seem highly possible that the degree of branching might be affected by the auxin mechanism.

Cell shape.—There are various differences in cell shape between the two species, particularly in the cells of the epidermis. Not enough work has been done to show whether or not these differences can be reduced to differences in one or a few basic coefficients.

Zygomorphy.—The flowers of both species are slightly zygomorphic, though in *N. alata* it is the corolla-limb which shows its bilateral symmetry most strikingly, while in *N. Langsdorffii* the expression of this tendency is stronger in the corolla-tube and throat. It is quite probable that these may be further manifestations of the basis for the vein-angle and leaf-angle differences.

In addition to the differences discussed above there are a number of minor ones whose expression is apparently limited to a single organ. Further genetical and physiological experimentation may show that some of these are further effects of the coefficients described above.

TABLE I

SUMMARY OF THE GENETIC COEFFICIENTS DIFFERENTIATING *N. ALATA* FROM *N. LANGSDORFFII*. "x," ORGANS IN WHICH THE ACTION OF THE GENETIC COEFFICIENT IS EVIDENT, "*," THE ORGAN IN WHICH IT CAN PROBABLY BE MEASURED MOST EFFICIENTLY

Genetic coefficients	Vegetative phase		Reproductive phase									Other coefficients of which this may be a further expression
							corolla					
	Axis	Leaf	Axis	Bract	Pedicel	Calyx	Tube	Throat	Limb	Stamen	Pistil	
(1) Cell size	x	x	x	x	x	x	x	*	x	x	x	(2)
(2) Cell elongation	x	x	x	x		x	*		x		x	
(3) Geotropic response	x	x	x	x	*			?	?			(2)
(4) Leaf-vein angles		x							?			
(5) Plastid color		x			x		x	x	*			
(6) Foliar periphery		x		x		x			*		x	
(7) Foliar base		x		x		x			*			(2)
(8) Pollen color										*		
(9) Time of blooming							x	x	*			(5)
(10) Scent							*					
(11) Inflorescence			*									(2)

A tabular summary of the coefficients which we have been able to detect so far is given in table I. It will be seen that eleven different coefficients have been recognized. Further work may possibly add a few more and will probably reduce certain of those listed as separate to a common coefficient. While there may well be differences which are not accounted for by the action of these eleven, they are certainly responsible for most of the total hiatus between the two species.

In this particular problem, as stated above, an estimate of the coefficients was desired as an aid in the genetic analysis. It may be well, however, by way of example, to point out how the estimate might have been used had our concern been the measurement of differences in populations involving the two species. Only two of the coefficients would be difficult to score, (9) and (10). The effects of both of these coefficients are greatly influenced by environmental factors, and it is also difficult to record them objectively. Of the remaining nine, one, (8), is seemingly manifest only in the pollen, and one, (11), only in the branching of the inflorescence. They would obviously have to be measured at those places. Coefficients (1) to (7), however, are all manifest in both the leaf and the flower, and each of the seven is expressed in various other ways. With the above estimate as a guide we should be able to decide where these seven differences might be measured most efficiently.

Were it not for this previous analysis it might have seemed that the leaf is the most promising organ for measurement. It is practically two dimensional, and its characteristics can all be expressed in simple quantitative terms by measuring and counting the veins and the vein angles. The leaf could furthermore be measured on young plants which had not yet reached the reproductive phase. The above analysis demonstrates, however, that the divergence between the two species can much more efficiently be measured in the flower. Though all seven coefficients are expressed in the leaf, its shape is the resultant of four of them, cell size, cell elongation, basal growth, and peripheral growth. Each of these can be determined in the flower with a single measurement, whereas in the leaf the raw

measurements are a complex resultant of all four. Furthermore, nearly all the veins and vein angles would have to be measured and given a thorough statistical treatment before they would be anywhere nearly as useful as the raw data obtained from the flower. The complexities of integrating and interpreting leaf measurements are illustrated in the statistical papers of Czeczott and her associates (Czeczott, '36, Jentys-Szaferowa, '38, Wiśniewski, '32).

The procedure suggested by the above analysis would be much simpler. The seven coefficients could best be measured as follows:

(1) Cell size.—While this is expressed throughout the plant, it can most efficiently be measured in those organs which are not affected by the other coefficients. The diameter of the pedicel or the diameter of the style might perhaps serve but those organs are so small that errors of measurement would be proportionately large. The throat of the corolla (from the insertion of the stamens to the angle marking the limb) is roughly the same proportion in both species (fig. 1, B), its cells seem to be of the same shape, and the limits to be measured are quite definite.

(2) Cell elongation.—This might also be measured in various parts of the plant, or it might even be measured by testing the effect of tissue extracts upon any standardized auxin indicator. The constricted tube of the corolla, however, offers the simplest measurement. In *N. Langsdorffii* it is less than half a cm. long. In *N. alata* it is 6 to 9 cm. While a small portion of this difference is due to (1), the difference in cell size, it is so slight as to be almost negligible by comparison. One measurement on the tube therefore is an almost perfect reflection of the basic difference in cell elongation between the two species.

(3) Geotropic response.—The angle of inclination made by the leaf, the branches of the inflorescence, or the pedicel of the flower might be measured. There is considerable variation among the leaves, however, depending upon the age of the plant, the time of day, the health of the plant, the position with

relation to the rosette, etc. A more comparable measure of (3) can be made by recording the angle made by the pedicel at the time of anthesis.

(4) Leaf-vein angles.—These are easiest to measure on the largest leaves. The best record we have been able to work out is the angle of the first vein above the petiolar portion of the leaf, on the first or second leaf above the rosette (these leaves are often injured, and more consistent results are obtained by choosing arbitrarily the most symmetrically developed of the two).

(5) Plastid color.—While this difference can be seen along the petiole and on the pedicel, particularly in old specimens, it is much more dramatic in the flower. It is there most readily scored on the inside of the flower. As has been previously reported (Anderson, '39), it is easy to recognize three grades of plastid color in the hybrids.

(6) Foliar periphery.—According to the hypothesis suggested above this coefficient accounts for differences in the leaf margin and the floral margin. It would be difficult or impossible to score in the leaf. In the flower it is one of the coefficients responsible for the difference in the width of the limb. The best measurement we have been able to develop so far is the maximum length of the largest corolla-lobe from its tip to the junction with the throat of the tube. This is probably also conditioned by differences in cell elongation and cell size so that a more direct measurement would be preferable.

(7) Foliar base.—Until the operation of the coefficient has been more definitely worked out it is difficult to decide where it might best be measured. For the present we are using the ratio previously adopted (Anderson, '39) for the lobing index (maximum lobe/adjacent sinus).

In the light of our present knowledge the most efficient measure of the divergence between these two species would be based upon the following, as shown in table 1: length of corolla-throat, length of corolla-tube, angle between pedicel and axis,

color of corolla, length of corolla-lobe, width of corolla-limb to the sinus, angle of basal leaf vein in first leaf above rosette, color of pollen. It will be noted (table 1) that all but one of these can be determined by a single measurement or notation. The original data should then be variously weighted and combined, depending upon the nature of the problem and the use to which the index of specific difference is to be put. Pollen-color and corolla-color differences, for instance, seem to be based on comparatively few genes. In an index designed to be roughly proportional to genic differences, they would be given less weight than measures such as tube length, which are apparently based upon a large number of genes.

It is an interesting fact that, though most of the eleven coefficients are expressed in various parts of the plant, all but one of them are most efficiently measured in the flower. Systematists for two hundred years have emphasized the importance of the flower (and its resulting fruit) in studying relationships between species, genera, families, and orders. It would seem probable that the condition found in these two species of *Nicotiana* must be general among the flowering plants. For reasons whose ontogenetical basis is as yet unknown the germ-plasms of the Angiosperms exhibit their characteristics more conspicuously in the reproductive than in the vegetative phase.

DISCUSSION

A method for the analysis of specific differences through the determination of their genetic coefficients has been developed as a general formula and illustrated by example. Its possible applications are in such different fields that it may be well to indicate three types of problems in which it might be used.

(1) The efficient measurement of specific and subspecific divergence.—The study of evolution by an analysis of variation within and between races and species is older than formal genetics. Until very recently the work of this school has been based on the assumption that if only enough measurements were made and studied with refined mathematical methods,

significant results would emerge. In other words, it was tacitly assumed that organisms vary at random. In our opinion this is putting the cart before the horse. How to measure a specific difference is a research problem which must be undertaken before one takes up the further problem of measuring that difference. As Fisher ('36a) has recently said in discussing the science of craniometry:

> It seems, indeed, undoubtedly true that the theoretical concepts developed . . . have lagged far behind the mass of observational material which has been accumulated. This may be partly due to the sheer magnitude of the programme which the energy of its founders sketched out, partly to an intuitive confidence, widely held in other fields, though everywhere difficult to justify, that, by amassing sufficient statistical material, all difficulties may ultimately be overcome.

The problem of working out even the barest estimate of the genetic coefficients which differentiate the races of men will certainly be much more difficult than the corresponding problem with which we are concerned in *Nicotiana.* Our experience in that latter seemingly unrelated field furnishes a number of suggestions. Biometric study of the races of men has been concentrated upon the skull though our experience with *Nicotiana* suggests that the form of the skull, like that of the leaf, is a complex resultant of many coefficients. It is therefore the worst kind of material for distinguishing between races, since even if there were a clear-cut difference in the basic coefficients separating the races, this would be obscured in its effect on the skull. There seem to be coefficients, for instance, which affect the long bones of the arm and leg in a fairly transparent fashion but cause complex changes in the skull and can be measured there only in an indirect and laborious way. Determinations of variation within and between the races of mankind would yield more significant results if they were based upon records of as many apparently unrelated characters as possible; hair color, hair texture, hair distribution, length of long bones, width of lip, shape of finger nails, finger-print patterns, eye color, and skin color, for instance. An object is much better defined when we describe its weight, color, size, texture, shape, and color pattern than when we have numerous careful

determinations of its weight alone. The latter has until recently been the method of the biometricians.

(2) The genetic analysis of differences between species.—One of the chief sources of evidence for evolutionary changes in the germ-plasm comes from the examination of hybrids between related species. Unfortunately nearly all the evidence which has been accumulated relates to characters rather than to genetic coefficients. To understand what the germ-plasm is doing in a species cross we need to have at least an estimate of the total difference between the parental species and data as to how that total difference is behaving in F_1, F_2, and back-crosses. In most of the published data only one or two obvious differences are followed in this fashion, and even with them the data are reported in terms of such characters as leaf length or plant height. As we have shown above, these characters are the resultants of a number of factors in which the action of any one is very much obscured. If the study of species hybrids could be preceded by at least a rough estimate of the main genetic coefficients which distinguish the parental species, we would have much more direct and dynamic evidence as to differences between related germ-plasms.

(3) The determination of phylogenetic patterns.—If an analysis similar to the one made above could be made for a group of related species it would provide unique data on evolution. While the attempt to consider all the differences between a group of related species in terms of their fundamental coefficients would admittedly be difficult it should not be impossible. Experience with a number of closely related species in several different genera has convinced us that such coefficients as those suggested above operate quite generally among the flowering plants. In *Iris, Acer,* and *Uvularia* closely related species have been found to differ by such general tendencies as absolute cell size, variation in cell size, amount of secondary thickening in cell walls, and geotropic orientation of branches of the axis and of the appendages (Anderson and Hubricht, unpublished). Such a study could most easily be

undertaken in a genus such as *Nicotiana* in which both the leaves and flowers are large and clearly differentiated into definite tubes, limbs, petioles, etc. While it would have to be frankly provisional it would provide a view of phylogeny which would be dynamic rather than static.

SUMMARY

1. From previous studies of closely related species it had been concluded that differences between such species are to be sought not in any one character but in harmoniously integrated tendencies (genetic coefficients) expressed more or less throughout the entire organism. A simple mathematical notation is developed for expressing the resulting morphological hiatus between two species.

2. By way of example, an estimate is made of the genetic coefficients which differentiate *Nicotiana alata* from *N. Langsdorffii*. Eleven such coefficients are suggested, the most important of which affect cell size, plastid development, and the auxin mechanism.

3. Estimates of genetic coefficients might be used in a number of different fields of biology. Their application to the following three problems is discussed: (1) The efficient measurement of specific and subspecific divergence; (2) The genetic analysis of differences between species; (3) The determination of phylogenetic patterns.

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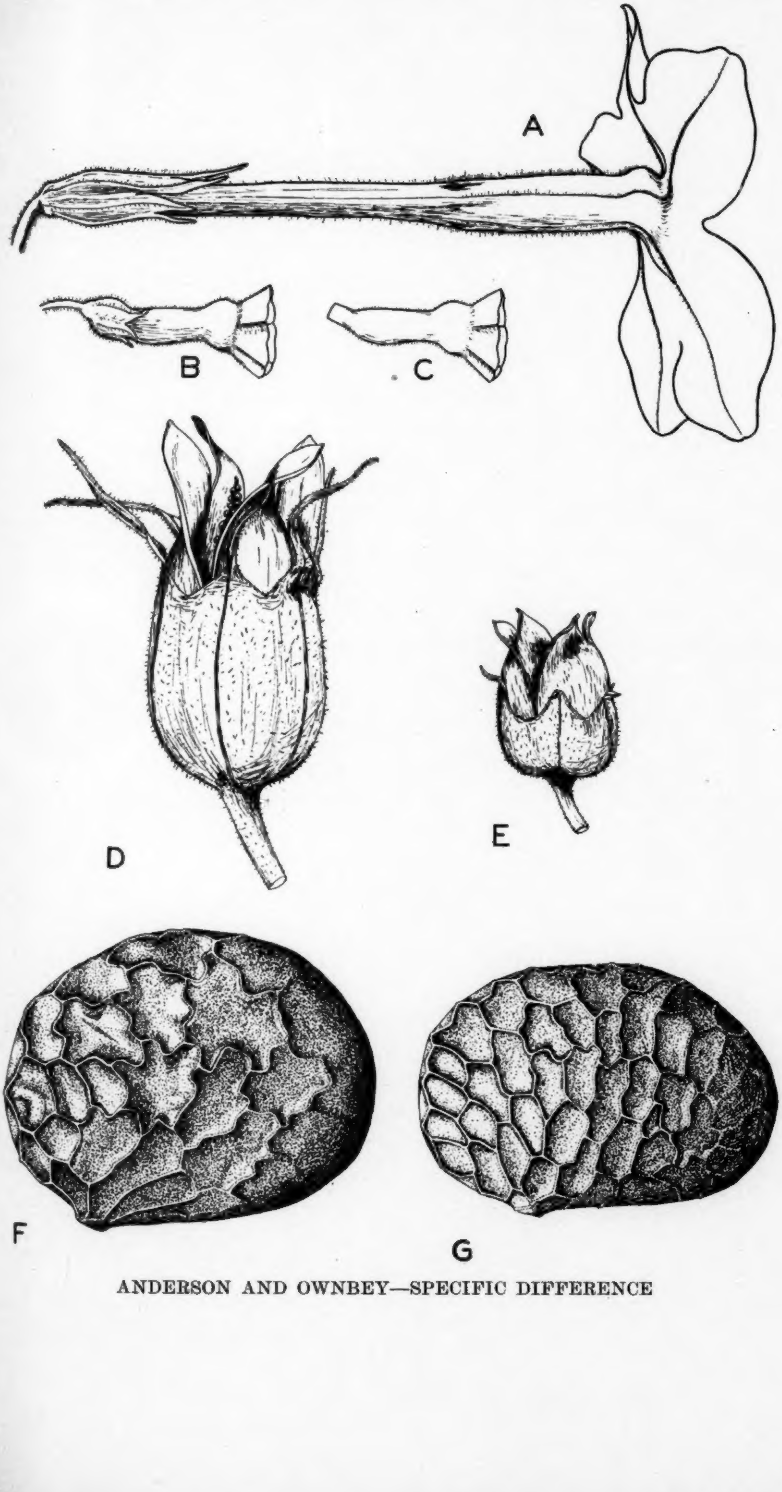
Explanation of Plate

PLATE 24

A. Flower of *Nicotiana alata* (× 7/10).
B. Flower of *N. Langsdorffii* (× 7/10).
C. Same, with calyx removed.
D. Ripe, opened capsule of *N. alata* (× 2).
E. Capsule of *N. Langsdorffii* (× 2).
F. Seed of *N. alata* (× about 50).
G. Seed of *N. Langsdorffii* (× about 50).



ANDERSON AND OWNBEY—SPECIFIC DIFFERENCE

MORPHOGENETIC DIFFERENCES BETWEEN NICOTIANA ALATA AND N. LANGSDORFFII AS INDICATED BY THEIR RESPONSE TO INDOLEACETIC ACID

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Introduction

An unusual opportunity for the application of the present knowledge of hormones to the investigation of morphogenetic differences between two closely related species is afforded by *Nicotiana alata* and *Nicotiana Langsdorffii.* The flowers of the two species are similar, but the difference in the size of the corolla parts suggests a possible interpretation in terms of hereditary response to growth substance. One of the chief differences lies in the constricted part of the corolla-tube (pl. 25, fig. 1). In *N. alata* its length is at least fifteen to twenty times that of *N. Langsdorffii,* whereas the whole corolla in the former is only four or five times the length of the latter. The epidermal cells of the tube of *N. alata* are extremely long; those of *N. Langsdorffii,* relatively short.

The work on several known genetic dwarf races of corn by van Overbeek ('35, '38) indicates that the varietal differences are due to genetic differences which regulate production, use, and inactivation of auxin. The experiments on *Epilobium* hybrids by Schlenker and Mittman, cited by Went and Thimann ('37), suggest this same relationship. If this hypothesis holds true for species of *Nicotiana* and the differences between them are due to differences in amount of hormone produced, then auxin should prove to be a limiting factor in *N. Langsdorffii* and its application to the corollas of this species should then cause an increase in size. If differences are due to differences in ability to use growth substance, then auxin should be a limiting factor in *N. alata* and additional amounts should increase

growth, whereas *N. Langsdorffii* would probably inactivate the hormone. On the supposition that the fundamental morphological distinctions between the two species are linked to genetic differences in ability to use or produce hormone, the following experiments were carried out.

Materials

Nicotiana alata Link & Otto and *Nicotiana Langsdorffii* Wienm. belong to a phylogenetic unit within the genus referred to by Priscilla Avery ('38) as the "alata-group." This is a group appearing to have a center of distribution in the Brazilian and northern Argentine area, and its members possess many morphological and genetic characters in common. The two above species have the same chromosome number and hybridize readily, hybridization occurring at times in nature.

Seeds of both species were planted in the greenhouse October 25, 1938, and flowered from February to April, 1939, inclusive. Flowers and stems were given similar treatment throughout the course of the experiment. One per cent and .5 per cent lanolin pastes were prepared by dissolving the indoleacetic acid (Eastman & Mallinckrodt) in melted lanolin. They were then stored in dark bottles. Due to the instability of indoleacetic acid in water solution the method of Brannon ('37) was followed, the auxin being dissolved in 95 per cent alcohol at a concentration of 4 mg./cc. The water solutions were prepared from this as needed. The alcohol was redistilled to insure purity. Tap water was used in all tests. Water controls were run as checks on solution treatments and pure lanolin controls were used for comparison with the hormone-containing lanolin pastes.

Experimental Methods and Results

Response of Flowers to Indoleacetic Acid

Flowers were studied first as they present the most striking difference between the two species. Four parts of the corolla were recognized; (1) the slender constricted portion of the tube to which the stamens are attached, herein called the tube,

(2) the widened part of the tube, herein called the throat, (3) the gibbous ring of the throat, and (4) the limb (fig. 1). These

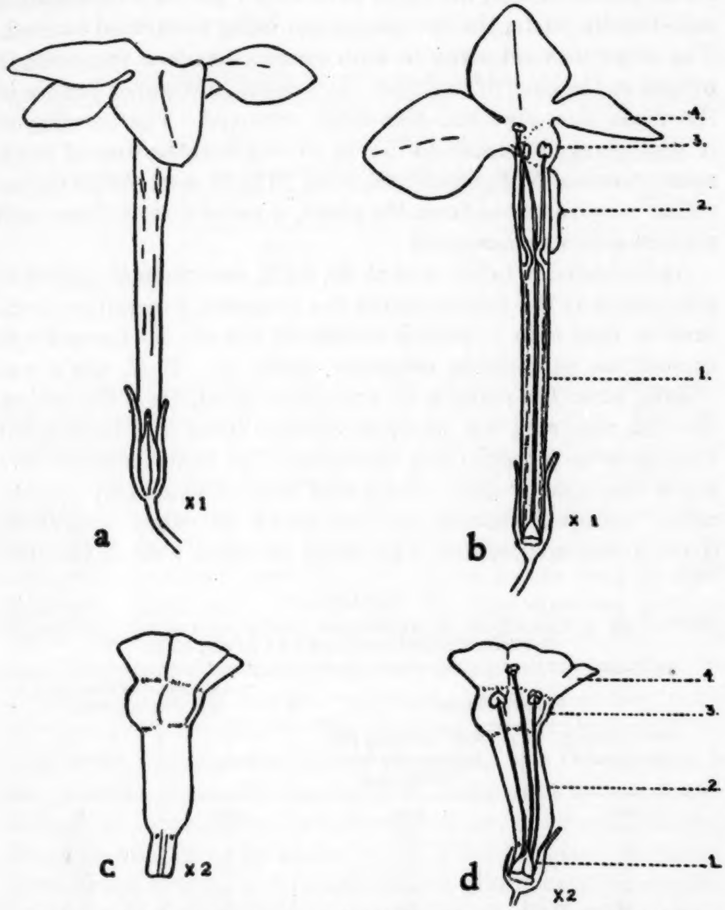

Fig. 1. a and b, external and internal structure of *Nicotiana alata* flowers, c and d, of *N. Langsdorffii*: 1, tube; 2, throat; 3, gibbous ring of throat; 4, limb.

parts show definite differences in cell structure and in growth rate. Direct and indirect methods of supplying additional hormone were used, the direct methods yielding the better results.

Lanolin paste was applied to the tube and throat of both species. In one series of tests one side was smeared with pure lanolin as a control, and the other side with 1 per cent indoleacetic acid-lanolin paste, the two pastes not being permitted to touch. The calyx was cut away in both species to allow the paste to extend to the base of the tube. As a check, untreated flowers of the same size also had the calyx removed. The corollas of *N. alata* ranged from 68 to 75 mm. in length at the time of treatment; those of *N. Langsdorffii,* from 13 to 17 mm. After the corollas were removed from the plant, a narrow strip from each treated side was measured.

As indicated in table I and pl. 25, fig. 2, growth in *N. alata* was stimulated on the side receiving the hormone, a negative curvature of that side resulting within 48 hours. *N. Langsdorffii* showed no perceptible response (table II). If *N. alata* was treated when too mature, no curvature resulted; if too young, the side receiving the hormone became fluted and bulged, but growth in total length was inhibited. The throat showed only slight response or none. Untreated flowers which had only the calyx removed showed no curvature or other alteration. Growth was accelerated regardless of which side of the tube

TABLE I

EFFECT OF APPLICATION OF HORMONE PASTE AND PURE LANOLIN TO OPPOSITE SIDES OF *N. ALATA* COROLLAS

Length of tube		Increment of treated side over untreated	
Side receiving pure lanolin	Side receiving 1% indoleacetic acid-lanolin paste	Length	Percentage
mm.	mm.	mm.	%
46	53	7	15.2
44	50	6	13.6
51	58	7	13.7
47	55	8	17.0
42	49	7	16.6
49	55	6	12.2
48	53	5	10.4
42	48	6	14.3
44	50	6	13.6
33	42	9	27.3
Av. 44.6	51.3	6.7	15.0

received the hormone. Curvature resulted whether or not pure lanolin was applied to the side opposite the one treated with hormone.

TABLE II

COMPARISON OF TUBE LENGTH AFTER TREATMENT OF OPPOSITE SIDES WITH HORMONE PASTE AND PURE LANOLIN *

Species	Length of tube		Increase of treated side
	Side receiving pure lanolin	Side receiving 1% indoleacetic acid-lanolin paste	
	mm.	mm.	%
N. alata	44.9	50.4	12.2
N. Langsdorffii	3.0	3.0	0.0

* Results are the average of 25 flowers each.

In a second series of tests two corollas of the same size were selected and lanolin was applied all around the tube. The controls received pure lanolin, the experimental flowers, 1 per cent indoleacetic acid-lanolin paste. In *N. alata* it was necessary to use two flowers from the same plant, as corolla-tubes maturing on a given parent at any time vary in length only two to five mm., whereas those from different parent stocks vary as much as 20 mm. (table III). The shorter the time elapsing between flower development, the less the variation on a given plant. The last flowers on a branch tended to be definitely smaller. In *N. Langsdorffii* the flowers varied so slightly that they could be taken from any plant. The calyx was again removed. The size of the flower at the time of treatment was the same as in the preceding test. Results with *N. alata* were not as clearly defined as in unilateral treatment but nevertheless indicated the same sensitivity to auxin found in the first test (table IV). Very young flowers of *N. alata* did not give consistent results; those nearly mature did not respond at all. Difficulty arose in finding suitable pairs of flowers of this species. As before, the tube and throat of *N. Langsdorffii* showed no measurable response (table V), except a similar inhibition of growth with both treatments.

TABLE III

VARIATION IN LENGTH OF UNTREATED *N. ALATA* COROLLA-TUBES

Plant no.	Number of tubes measured	Longest	Shortest	Average	Range of variation per plant
		mm.	mm.	mm.	mm.
1	10	55	50	52.1	5
2	7	55	50	52.3	5
3	10	47	45	46.3	2
4	7	54	50	52.5	4
5	10	56	53	54.2	3
6	8	46	42	45.0	4

TABLE IV

LENGTH OF COROLLA-TUBES AND THROAT OF *N. ALATA* TREATED ALL AROUND THE TUBE WITH HORMONE PASTE

Pair no.	Pure lanolin control		1% indoleacetic acid-lanolin paste	
	Tube	Throat	Tube	Throat
	mm.	mm.	mm.	mm.
1	45	25	47	25
2	52	23	55	23
3	51	22	54	24
4	53	23	55	23
5	53	24	54	24
6	48	24	55	24
7	49	27	54	29
8	42	30	47	30
9	32	20	39	24
10	52	23	55	
Average	47.7	24.1	51.5	25.0

TABLE V

LENGTH OF PAIRS OF COROLLA-TUBES FOLLOWING TREATMENT ALL AROUND THE TUBE*

Species	Pure lanolin	1% indoleacetic acid-lanolin paste	Increase
	mm.	mm.	%
N. alata	47.6	51.5	8.2
N. Langsdorffii	3.0	2.9	–3.0

* Results are averages from 25 flowers.

Immature flowers were cut off and floated in a solution of 10 mg. indoleacetic acid per liter of water and measured after 48 hours. A comparable group was floated in water. *N. alata*

corollas of various length were tried, but the only consistent results were that they seemed to mature more slowly than the water controls. In preliminary tests with *N. Langsdorffii* those corollas 17 to 19 mm. in length seemed to show definite increase in limb length and spread, also more blanching than average; a few plants normally showed this tendency. Repetition with two separate groups of fifty corollas each showed this increase in limb length to be consistent (table VI). The corollas had been sorted in pairs of equal size at the beginning of the experiment and one of each pair placed in hormone solution and one in water. If there was any variation in size, the water received the larger flower.

TABLE VI

LENGTHS OF PARTS OF COROLLA OF *N. LANGSDORFFII* FLOATED 50 HOURS IN HORMONE SOLUTION*

Treatment	Limb	Tube and throat	Total length	Limb spread †
	mm.	mm.	mm.	mm.
10 mg. indoleacetic acid/liter	5.0	23.1	28.1	15–17
Control	4.1	22.0	26.1	11–13

* Results are the average of 50 flowers.
† Ten largest only were measured.

Among the various indirect methods of supplying hormone to the flower was the application of lanolin paste to the stem below the inflorescence. When 1 per cent paste was used, there resulted an inhibition of flower buds above the treated area in *N. alata*, a slight inflation of the calyx being followed by yellowing and abscission. The growth of buds on older stems was not immediately checked, but the younger buds were affected. *N. Langsdorffii* showed definite local response such as stem curvature, but this self-fertile species matured seeds as usual above the treated area unless the plants were given extremely heavy doses when very young.

On either side of the stem below the inflorescence strips one-half inch in length were coated with the .5 per cent lanolin paste at three-day intervals. Not a sufficient number of plants of *N. alata* were treated to give conclusive results in a species

as variable as this. However, tube growth seemed to be somewhat accelerated and the average length of the tubes was somewhat greater than in the untreated flowers. Repeated applications often led to an inhibition of growth above the treated area as with the more concentrated paste. The frequent use of pure lanolin caused no change. Two branches of each of several plants were treated, one receiving the hormone, and one pure lanolin. After a time the former ceased to grow but the latter continued development, thus indicating that the hormone was very probably the cause of the inhibition. *N. Langsdorffii* showed no response to the .5 per cent lanolin paste except slight local curvature if application was uneven.

Cut inflorescences of both species were placed in water solution of indoleacetic acid and also in water. To be sure that results were due to the hormone in solution and not to the alcohol which was used to dissolve it, equal amounts of alcohol were added to both. Neither showed any appreciable acceleration of flower size, but a concentration of 10 mg. per liter caused inhibition of floral development in *N. alata*. Solutions of 5 mg. per liter or less resulted in neither bud inhibition nor noticeably larger flowers. The flowers of *N. Langsdorffii* were the same size in the water control and in the auxin solution. While both species keep well when cut, in hormone solution they seemed to keep longer than in water.

In an effort to determine the source of growth substances, styles and stigmas were removed from the flowers of both species while they were still young. In *N. Langsdorffii* it is a simple procedure to open the limb with fine forceps and to reach the style without damaging the corolla and stamens. Except with almost mature specimens of this species the flowers drop off before reaching maturity, usually within 24 to 48 hours after removal of the style. The younger the flowers, the sooner they drop off. The treated flowers were marked with blue on the calyx. Recent experimentation by Bonner and English ('37, '38) has indicated the formation of the wound hormone, traumatin, as a result of tissue damage. This could be a source of error, especially in *N. alata,* as it was impossible to reach the

pistil with available instruments without damaging the corolla and stamens. Therefore, in some of the flowers the limb was cut away with a sharp razor. In half of these the stigma and part of the style were removed; in the other half they were left intact. Even with the limb removed, it was difficult to reach the pistil. The cut inflorescences were then placed in water and covered with a bell jar to reduce transpiration. Previous experience had shown that the flowers on cut inflorescences matured satisfactorily in water. Those flowers with pistils removed tended to develop shorter tubes or to drop off, but some grew normally. On the plants, ten young corollas of various sizes were slit down one side of the tube and the style severed close to the base; others were slit, but the style left intact as controls. Both sets usually matured and the controls were then measured and examined for style injury. Again results were not consistent, but the flowers with severed styles tended toward shorter tubes; the throats were not greatly affected. Curvature toward the injured side developed in both.

Normal cell structure and growth rate of the corolla parts were studied as an aid in understanding the reactions of these parts to indoleacetic acid. Two series of ten corollas of each species were marked off into tube, throat, gibbous ring of throat, and limb by means of fine blue lines. These parts were measured at 24-hour intervals until growth stopped. In *L. Langsdorffii* measurements of growth were started as soon as the corolla parts could be easily distinguished; in *N. alata,* when the corolla was approximately 35–45 mm. in length. Figure 2 represents graphically measurements for the five days preceding full development in *N. alata* and the four days preceding full development in *N. Langsdorffii.*

Cell structure was not studied in detail, but a microscopic examination of the epidermal cells of the various parts was made in order to compare their size and shape. In *N. alata* the epidermal cells of the corolla-tube are extremely long and are similar to those of the *Avena* coleoptile in general shape (fig. 4A), whereas in *N. Langsdorffii* they are comparatively short, almost isodiametric (fig. 4B). As the growth rate of the

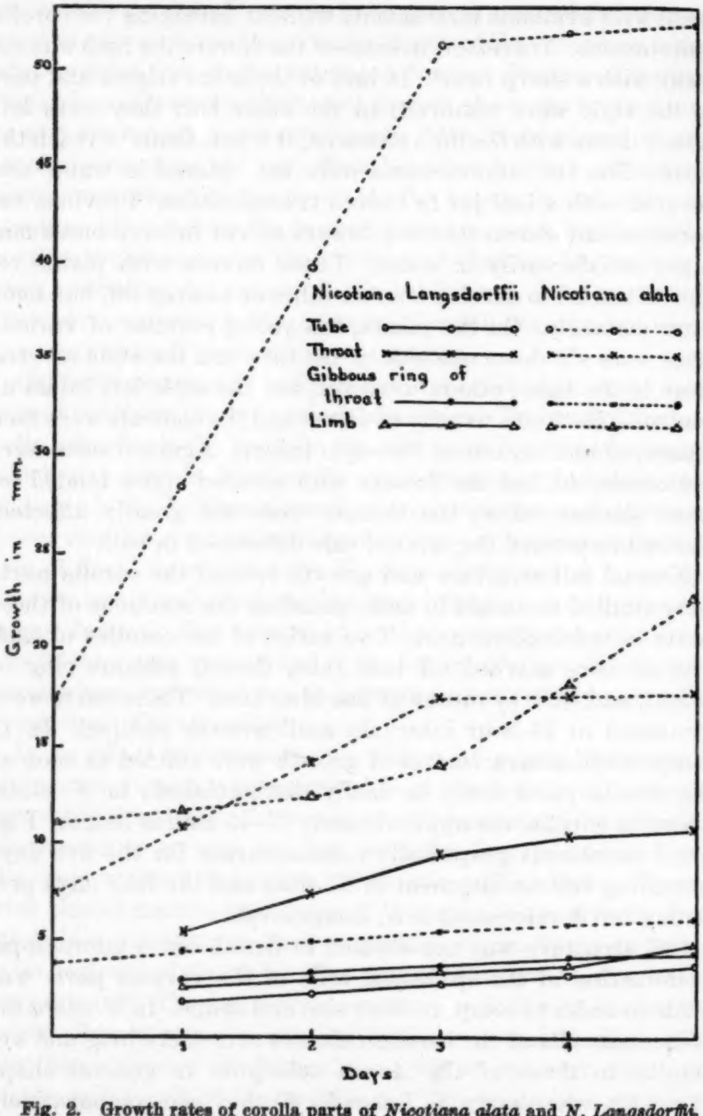

Fig. 2. Growth rates of corolla parts of *Nicotiana alata* and *N. Langsdorffii*. Results are the means of 15 corollas.

tube of *N. alata* is very rapid and that of *N. Langsdorffii* very slow (fig. 3), a correlation between growth rate and cell elongation is indicated. The cells of the throats of the two species are

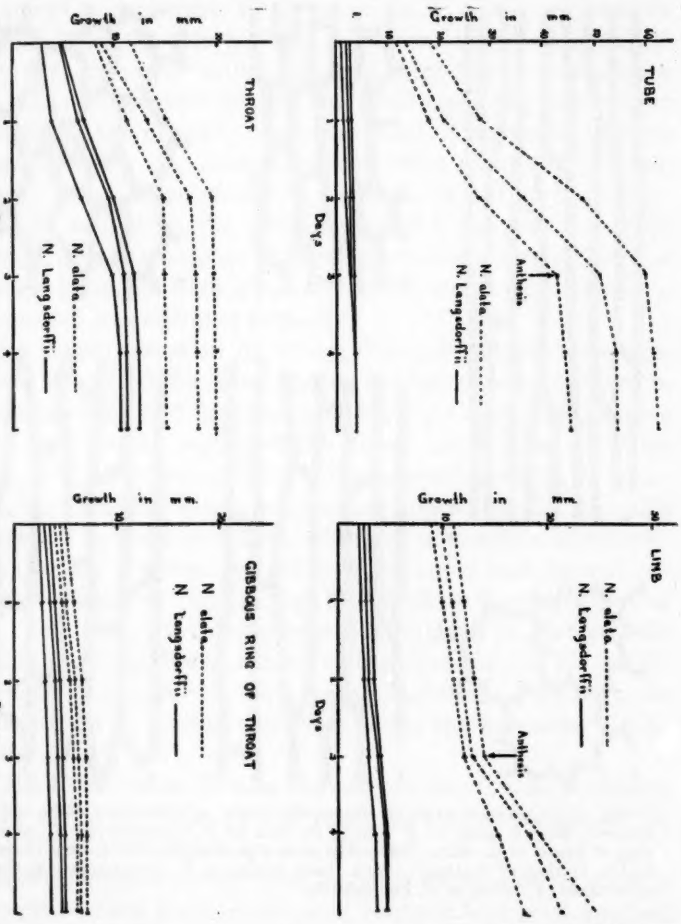

Fig. 3. Growth rates of corolla parts of *Nicotiana alata* and *N. Langsdorffii*. Three typical flowers used for each.

similar in size and shape (fig. 4E, F) and growth rate (fig. 3). They are shorter than those of the *N. alata* tube. In both species the cells of the gibbous ring of the throat show a grad-

ual transition from the longer ones of the throat to the iso-diametric cells of the limb (fig. 4C). The two species also have similar growth curves (fig. 3). Many stomata are present.

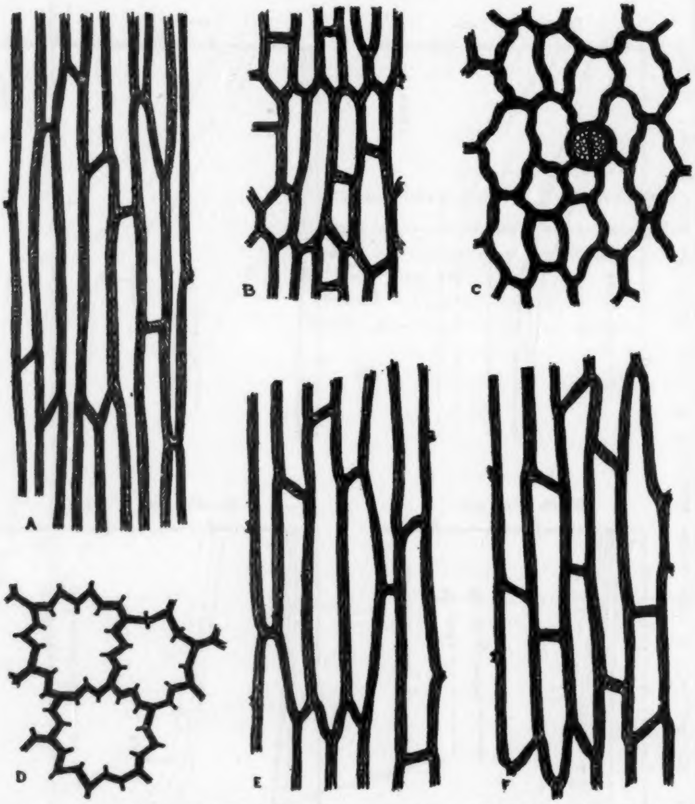

Fig. 4. Epidermal cells of the corolla parts of *Nicotiana alata* and *N. Langsdorffii:* A, tube of *N. alata;* B, tube of *N. Langsdorffii;* C, gibbous ring of throat of *N. alata* (these cells show a gradual transition from throat to limb); D, limb of *N. alata;* C and D are similar in *N. Langsdorffii;* E, throat of *N. alata;* F, throat of *N. Langsdorffii.*

While cells of the limb correspond very closely in the two species (fig. 4D), those of *N. alata* grow more rapidly, especially during the last few days of development (figs. 2–3). It is interesting that in *N. alata* the growth curve of the limb rises at

about the time of anthesis as the tube and throat curves flatten out.

STEM RESPONSE TO INDOLEACETIC ACID

A peculiar curvature of the stem in *N. alata*, apparently resulting from the action of the hormone, suggested a limited study with stems of both species. Young flower stalks were used; old ones in which growth had practically stopped did not respond. If the primary stalk was used, it was cut off 45 to 60 cm. from the tip; secondary ones were of necessity much shorter. These were placed in solutions of (a) 10 mg. of indoleacetic acid/liter, (b) 5 mg./liter, (c) 1 mg./liter, and (d) tap water. Solutions were changed every other day until three or four treatments were given. Then the stems were placed in water which was changed as needed.

With a concentration of 10 mg./liter, *N. alata* showed increased growth on the side opposite the insertion of the leaf in the younger parts of the stem and therefore marked curvature of the stem in the region of the upper leaves (fig. 5). This occurred in from two to five days from the beginning of treatment, the younger stems responding more quickly. At this concentration the flower buds which were nearly mature continued normal development, while the younger buds turned yellow and abscissed (pl. 26, fig. 2). With a concentration of 5 mg./liter, the stem curvature was slight and the flowers matured in the same time as those of the controls (pl. 26, fig. 1). No effect was apparent with weaker solutions, nor with the small amount of alcohol used to dissolve the hormone, $2\frac{1}{2}$ cc. per liter.

While *N. Langsdorffii* also showed curvature with a concentration of 10 mg./liter, it was much less pronounced (pl. 26, fig. 2). The flower buds were not affected.

Roots developed freely from the stem surface of *N. alata* in the region where indoleacetic acid solution had been applied. Both 5-mg. and 10-mg./liter solutions stimulated abundant root production. Stems also developed roots without treatment, but only near to the base, and they were not as numerous as on the treated stems. These results are in agreement with

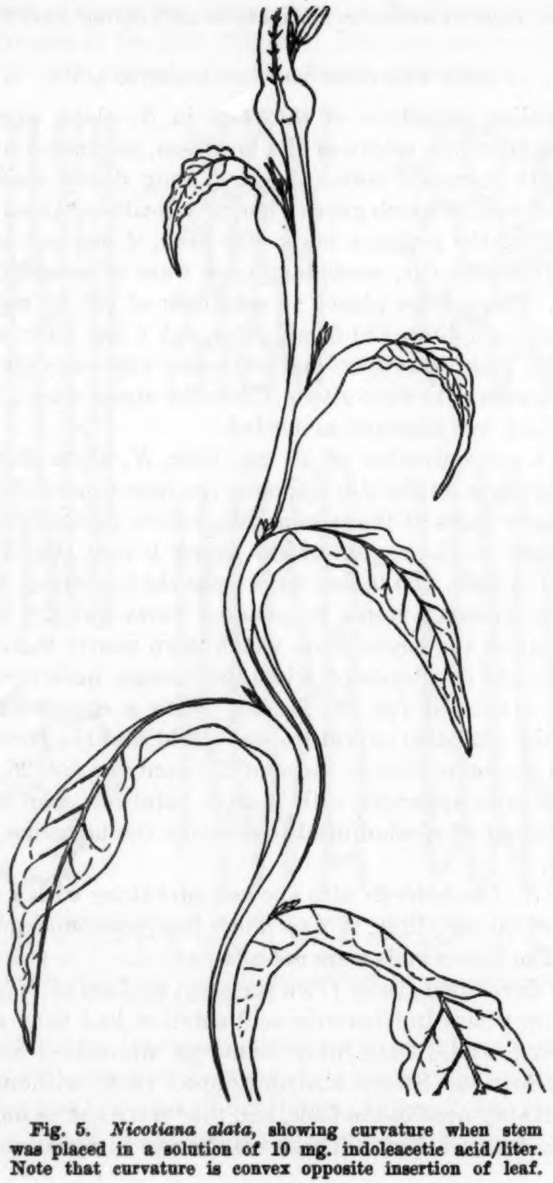

Fig. 5. *Nicotiana alata,* showing curvature when stem was placed in a solution of 10 mg. indoleacetic acid/liter. Note that curvature is convex opposite insertion of leaf.

those of Stuart ('37) and Pearse ('38), who have found root development accelerated by auxin. According to Brase ('37), failure to produce roots was not overcome in many species by use of synthetic growth substances. This seemed to be true of *N. Langsdorffii,* which did not produce roots either with or without treatment.

As previously mentioned, applications of 1 per cent indoleacetic acid-lanolin paste will induce local curvature of the stems in the treated region in both species. Even with one treatment, roots will finally break through the epidermis in *N. alata.* Inhibition of floral development above the treated area was complete, although branches below matured normally (pl. 26, fig. 3). *N. Langsdorffii* showed no inhibition and no root formation, but matured its flowers and seeds normally in spite of extreme curvature (pl. 26, fig. 4). Growth was checked in this species only when high concentrations were used daily on young stems. External roots did not appear. A concentration of 0.5 per cent indoleacetic acid in lanolin produced the same type of result as the more concentrated paste, but to a less degree. *N. alata* showed gradual inhibition of growth above the treated area; very few roots developed.

Discussion

The response of a plant to additional growth substance is conditioned by its sensitivity and its tendency to inactivate auxin. The curvature of the corolla-tube in *N. alata* following application of indoleacetic acid-lanolin paste indicates that this species has the ability to use additional hormone. This was also suggested by the increase in length of corolla-tubes following application of hormone paste all around the tube. Like the cells of the *Avena* coleoptile, the tube cells of *N. alata* respond readily to growth substance. Microscopic examination indicates that this increased growth in *N. alata* is the result of increased cell elongation rather than division. Cells of this type which in nature elongate rapidly are thought to be often capable of using auxin for further elongation. The short tube cells of *N. Langsdorffii* show no response to hormone with any

method used. This indicates a probable inherent lack of ability to utilize growth substance, possibly due to lack of sensitivity to it or to its inactivation by oxidative destruction or enzyme activity. The difference in the tubes of the two species, not only in size but in cell structure and growth rate also, is probably due to the heritable genetic difference in the ability of their cells to respond to growth substance.

The throats of the two species are similar in cell size and growth rate. In neither species did the throat show marked response to addition of growth substance. The limb of *N. alata* grew more rapidly than *N. Langsdorffii* during the last few days of development. The development of the corollas floated in hormone solution possibly gives some insight into the effect of the hormone. Isolated corollas of *N. alata,* in which growth is normally very rapid, showed no increased growth over controls, but both were considerably shorter than normal. Recent work of Alexander ('38) and Stuart ('38) has indicated that one of the effects of hormones such as indoleacetic acid in stimulating growth is the mustering of the food factor. *N. alata* normally grows with such rapidity that the food present in isolated corollas is probably soon exhausted and further growth then limited. *N. Langsdorffii,* which is comparatively unresponsive to indoleacetic acid in other parts of the corolla, shows increased growth of the limb when floated in hormone solution. This tendency was noted also after the application of lanolin paste, although exact measurements were not made. If auxin is considered to be one of the factors necessary for growth, it may be that not enough reaches the limb to allow optimum development and thus it becomes a limiting factor. Perhaps this explains why with direct application these cells are stimulated to increased growth.

Since it is generally the terminal bud which produces hormone, the stigma and style, being considered the possible counterpart of the terminal bud, were removed to study the effect on the flower. That *N. Langsdorffii* flowers wilt and drop off after removal of these parts, unless nearly mature at the time, was considered as evidence that they may control the de-

velopment of the flower in some way. Went and Thimann ('37) make the general statement that auxin is one of the many factors necessary for the ordinary growth process and that "without auxin, no growth." Absence of auxin may thus account for the lack of development. However, Avery and LaRue ('38) have found that decapitated *Avena* coleoptiles will continue development on agar culture containing food and minerals for as much as six days after all measurable traces of growth substance have been used up. The hormone is therefore probably not a necessity for growth although it does stimulate or "catalyze" it. On the other hand, *N. alata* flowers are often developed after the removal of the stigma and part of the style, although with shorter tubes than usual. Growth is limited, but not often stopped. This may be due to inhibition caused by the wound hormone, traumatin, or it may be that some other source supplies the growth substance. It is also possible that all of the long style was not removed and that there is a "regeneration of a physiological tip"; or that the part of the style remaining still produces enough auxin for limited growth.

A study of the flowers of the two species seems to indicate that their differences lie in genetic differences in response to hormone, *N. alata* being sensitive to it, *N. Langsdorffii* lacking in ability to use it or inactivating it.

When cut young flower stalks were placed in hormone solution, the "unphysiologically" high concentration of indoleacetic acid—10 mg./liter—was carried upward in the transpiration stream (Hitchcock and Zimmerman, '35). This is not in opposition to the usual concept of polarity expressed by Went and Thimann ('37). The curvature of the young stems was brought about by greater growth on the side opposite the leaves. The lessened growth in the region of the leaf insertion may have been caused by a lower concentration of hormone in the stem owing to its passage into the leaf. Old stems show no curvature because the aging of the cells renders them unresponsive. *N. alata,* with characteristic sensitivity and good transport facilities, curved strongly, the degree of curvature depending upon age of the cells and concentration of the hor-

mone. In the cut stems of *N. Langsdorffii* the hormone was probably likewise carried upward in the transpiration stream, but the resulting slight curvature showed little use of the additional hormone. It is possibly significant that the total height of *N. alata* is greater, 150 to 190 cm., than of *N. Langsdorffii*, 110 to 120 cm. Both species respond to local application of 1 per cent indoleacetic acid-lanolin paste in young stem regions. As this is also an "unphysiologically" high concentration of hormone, unequal application of it stimulates *N. Langsdorffii* locally to marked curvature but no roots appear. Due to the destruction of the hormone in transport or to lack of sensitivity of this plant to it, the flowers and other parts were not affected. *N. alata* showed similar local curvature of the stem with formation of adventitious roots.

The effects from both lanolin application and solution treatment are not limited to the stems of *N. alata*, but are extended to the flower stalk. With the concentrations used, growth was completely inhibited and flower buds and upper nodes of the flower stalk were eventually killed. This again seems to indicate that inactivation does not occur in *N. alata*, as a high concentration of the substance apparently reaches the flowers.

Because of the great sensitivity of the cells of *N. alata* to hormone, the concentrations used proved to be toxic to the younger cells. That very young corollas do not respond favorably to applications of lanolin paste might be explained by this fact. The upper tissue is perhaps partly inactivated by the mobilization of food materials in the treated area of *N. alata* as this region responds with the formation of numerous roots; and development of roots requires food material. The differentiation of the tissue to form roots on the stem would possibly interfere mechanically with transport and aid in causing inhibition above the region of application. Cut flower stalks of *N. alata* produced some basal roots without any treatment, but more if treated with 5 or 10 mg. indoleacetic acid/liter. *N. Langsdorffii*, however, produces none under such conditions, thus giving additional evidence that *N. alata* probably is hereditably more able to use growth substance. As is

usually true, *N. alata* roots more quickly when treated. It has been suggested by Went ('38, '39) and Cooper ('38) that indoleacetic acid stimulates rooting by causing a redistribution and then an activation of the rhizocaulin already present in the tissue.

Went and Thimann ('37), in the light of the work of Lehman, Hinderer, Schlenker, and others, on *Epilobium* hybrids, suggest that possibly the sensitivity to growth hormone might be determined by the genes; the auxin production, by the cytoplasm. The above results suggest that morphogenetic differences in hormone response probably account for the principal differences between the two species studied.

Summary

1. The corollas and flower stalks of *Nicotiana alata* and *Langsdorffii* were used in studying the role of growth hormones in morphogenesis.

2. The corollas were found to serve as especially favorable material since they follow the same general growth pattern, but differ markedly in cell elongation. Results indicate that *N. alata* generally has greater ability to use additional hormone than *N. Langsdorffii.* The former also is more sensitive and smaller amounts prove toxic to young cells. Corollas of *N. Langsdorffii* give evidence of inactivation of growth hormone except in the limb.

3. Young flower stalks inserted in hormone solution respond by curvature on the side opposite the leaf insertion. The response is much greater in *N. alata* than in *N. Langsdorffii,* and in both species depends upon the age of the stem and the concentration of the hormone.

4. Experiments indicate that many of the principal differences between the two species lie in a genetically controlled difference in their ability to use hormone.

I wish to take this opportunity to express my appreciation to Dr. Edgar Anderson, of the Henry Shaw School of Botany, for suggesting the problem and for the use of the greenhouse and materials; to Dr. George T. Moore, Director of the Mis-

souri Botanical Garden, for the use of the library; to Dr. Edna L. Johnson, of the University of Colorado, for her assistance and encouragement in this problem, submitted as partial fulfillment of the requirements for the degree of Master of Arts at the University of Colorado.

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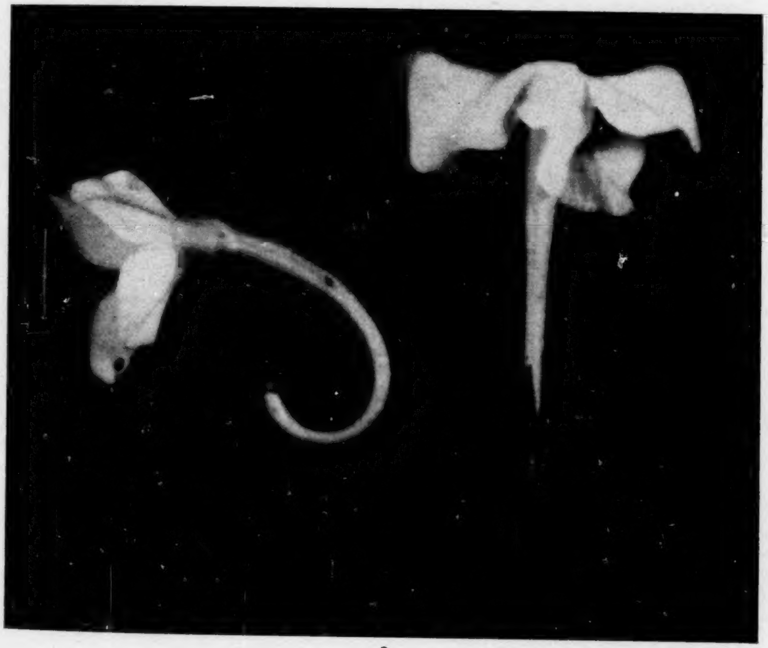
Explanation of Plate

PLATE 25

Fig. 1. At left, inflorescence of *Nicotiana alata;* at right, inflorescence of *Nicotiana Langsdorffii.*

Fig. 2. Curvature of *Nicotiana alata* in response to treatment with 1 per cent indoleacetic acid-lanolin paste. In flower at left, right side of tube had been treated with hormone paste; left side with pure lanolin. Flower at right was untreated.

1



2

NAGEL—NICOTIANA ALATA AND N. LANGSDORFFII

EXPLANATION OF PLATE

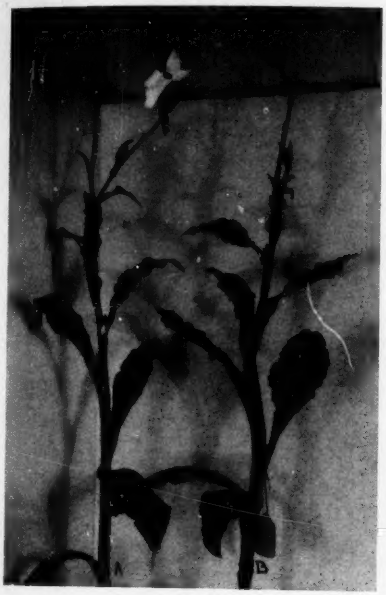
PLATE 26

Fig. 1. Stems of *Nicotiana alata* which were placed in a solution of indoleacetic acid. A was treated with a solution of 5 mg./liter; B, with a solution 10 mg./liter. Note greater curvature and bud inhibition in the latter.

Fig. 2. Stems of *Nicotiana* kept in a solution of 10 mg. indoleacetic acid/liter for four days. Left, *N. Langsdorffii;* right, *N. alata.* Note greater bud inhibition and stem curvature in *N. alata.*

Fig. 3. *Nicotiana alata* stem treated with 1 per cent indoleacetic acid-lanolin paste. Note the inhibition of growth and abscission of buds above the treated area. The white spots in the treated area are roots.

Fig. 4. *Nicotiana Langsdorffii* stem showing curvature which followed treatment with 1 per cent indoleacetic acid-lanolin paste. Floral development is not checked and seeds mature as usual above the treated area.



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NAGEL—NICOTIANA ALATA AND L. LANGSDORFFII

MONOGRAPH OF THE NORTH AMERICAN SPECIES OF THE GENUS EPHEDRA[1]

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Introduction

The importance of the drug, ephedrine, secured from Asiatic species of *Ephedra,* in the treatment of nasal colds, asthma and hay fever has attracted wide attention to this genus. Workers in range management have investigated the relative palatability of various species, and students of phylogeny have speculated on the role of the genus in a phylogenetic sequence. These last have contributed to the confusion in the terminology for, in addition to applying descriptive terms derived from Angiosperm and Gymnosperm sources, they coined new ones. Unfortunately, many of the investigations are of little value because the material was incorrectly identified or was a mixture of more than one species.

Correct determination of material is extremely difficult, for the number of species has nearly doubled since the publication of the last monograph of the entire genus and many of them were originally described from sterile or from staminate material. Approximately two-thirds of collected specimens cannot be identified with certainty from existing descriptions. The present study determines the correct application of names, proposes several new ones for hitherto undescribed forms, delimits the North American species, and provides means for their accurate determination. The South American species are not discussed in the present work but will be taken up later.

Manuals, floras, and other works which recognize species of

[1] An investigation carried out at the Missouri Botanical Garden in the Graduate Laboratory of the Henry Shaw School of Botany of Washington University and submitted as a thesis in partial fulfillment of the requirements for the degree of doctor of philosophy in the Henry Shaw School of Botany of Washington University.

Issued November 30, 1939.

Ephedra are not cited in the text of this paper unless they are necessary for bibliographical reasons. Such citations might indicate acceptance of the entities as delimited in those works, which is usually not the case. The more important publications may be found in the history, generic and specific synonymy, and bibliography.

History

Ephedra has been known and used medicinally in China for about five centuries. Its general acceptance by Western pharmacists is comparatively recent. Groff and Clark[2] summarize the history of its use in medicine and indicate the scant value many analyses have because the material upon which they are based is not definitely determined. To be serviceable, analyses of the plants should be accompanied by the name of the species and the location of herbarium material, the locality in which it grew, the date of collection, the parts of the plant analyzed, and the methods of drying, of extraction and of measurement.

The genus *Ephedra* was definitely established by Linnaeus in the 'Species Plantarum'[3] and in the 'Genera Plantarum'[4] of 1753 and 1754 respectively. Two species, *E. distachya* and *E. monostachya,* were included by him in the former publication. The first North American species to be described was *E. antisyphilitica* in C. A. Meyer's[5] monograph of the entire genus. In 1848 Torrey[6] recorded another species as "*Ephedra occidentalis*" which was later validly published by Watson[7] as *E. trifurca.* Watson[8] described three species, *E. californica, E. nevadensis,* and *E. Torreyana,* in 1879; and four years later[9] published *E. aspera* and *E. pedunculata* from the notes of Engelmann. The second and latest monograph of the genus

[2] Groff & Clark in Univ. Calif. Pub. Bot. 14: 247–282, *charts 1–6.* 1928.
[3] L., Sp. Pl. 2: 1040. 1753.
[4] L., Gen. Pl., ed. 5, 462. 1754.
[5] Meyer, C. A. in Mém. Acad. Imp. Sci. St. Petersburg. VI, Sci. Nat. 5: 291. 1846.
[6] Torr. in Emory, Mil. Reconn. 151. 1848.
[7] Wats. in U. S. Geol. Surv. Fortieth Parallel [Bot. King's Exp.] 5: 329. 1871.
[8] Wats. in Proc. Am. Acad. 14: 299. 1879.
[9] Wats. in Proc. Am. Acad. 18: 157. 1883.

appeared in 1889, and in it Stapf[10] published two subvarieties of *E. nevadensis,* subvar. *paucibracteata* which is synonymous with the species, and subvar. *pluribracteata* which is a synonym of *E. viridis* Coville[11] published in 1893. In 1909 the most southern of the North American species, *E. compacta,* was described by Rose.[12] Johnston[13] in 1922, and Cory[14] in 1938, described *E. peninsularis* and *E. Reedii* respectively, both of which are synonyms for *E. aspera.* Groff and Clark[15] published a survey of the North American species in 1928 as an aid to the study of the drugs contained in plants of the genus. Nelson[16] described *E. fasciculata* from vegetative material in 1935, and in the same year Coville and Morton[17] proposed *E. funerea,* and Reed[18] *E. texana,* which is synonymous with *E. antisyphilitica. E. Coryi* Reed[19] was published in 1936, and in 1938 *E. Reedii* Cory and *E. antisyphilitica* var. *brachycarpa* Cory[20] appeared.

General Morphology

The North American members of the genus are, with the exception of the clambering *E. pedunculata,* erect woody shrubs. All species have reduced scale-like leaves and photosynthetic young stems.

Seedlings.—The tap-root of the young seedlings soon branches to form a fibrous root system with numerous root hairs and a diarch or occasionally triarch stele. Two cotyledons are produced. The first leaves of all species are borne in pairs, and the ternately leaved forms show the whorled arrangement only after several pairs have been produced. In *E.*

[10] Stapf in Denkschr. K. Akad. Wiss. Wien **56**²: 1–112, *pls. 1–6, 1 map.* 1889.
[11] Coville in Contrib. U. S. Nat. Herb. **4**: 220. 1893.
[12] Rose in Contrib. U. S. Nat. Herb. **12**: 261. 1909.
[13] Johnston in Univ. Calif. Pub. Bot. **7**: 437. 1922.
[14] Cory in Rhodora **40**: 216. 1938.
[15] Groff & Clark in Univ. Calif. Pub. Bot. **14**: 247–282, *charts 1–6.* 1928.
[16] Nelson in Am. Jour. Bot. **21**: 573. 1935.
[17] Coville & Morton in Jour. Wash. Acad. Sci. **25**: 307. 1935.
[18] Reed in Bull. Torr. Bot. Club **62**: 43. 1935.
[19] Reed in Bull. Torr. Bot. Club **63**: 351, *figs. 1–2.* 1936.
[20] Cory in Rhodora **40**: 218. 1938.

Torreyana the endosperm remains attached to the base of the stem by means of a foot, although Voth[21] indicates that *Ephedra* is the only Gnetalean genus lacking this organ.

From 420 seeds of *E. trifurca, E. Torreyana, E. antisyphilitica, E. aspera, E. Coryi* var. *viscida* and *E. viridis,* in about equal numbers gathered in May and June and planted in September, only eleven seedlings were obtained, nine of *E. Torreyana* and one each of *E. trifurca* and *E. Coryi* var. *viscida.*

No seedlings and only a very few young plants were observed during two seasons of field work, and it is probable that the most frequent type of propagation is by means of divisions of buried stems. It has been suggested that the peridermal diaphragm at the base of each internode which allows the stems to fragment readily is a device to aid propagation by the rooting of the segments. It is highly improbable that many of these segments would root under the xerophytic conditions characteristic of the habitat of *Ephedra.*

Stem.—The green stem is solid, furrowed, and usually roughened by the cutinized and thickened epidermal walls which contain calcium oxalate. Blunt papillae occur on the thickened walls, and the size and number of these determine the degree of asperity of the stem. While the papillae vary greatly within a species, the width of the furrows and ridges and the number of stomata per unit of area remain nearly constant. The epidermal cells upon the ridges are longer than those in the furrows and are underlain by a bundle of hypodermal fibers.

In most species the stomata are confined to the furrows and usually are sunken, although in *E. antisyphilitica, E. compacta* and *E. pedunculata* the striation is not extensive and the stomata are scattered over the entire surface. The stomatal pits are prominent in these three species, especially in *E. compacta.* The size and shape of the stomata vary with the species.

Stomatal frequencies are relatively constant for each species, provided stems of the same age and from plants in almost similar habitats are examined. While it would be bet-

[21] Voth in Bot. Gaz. 96: 298. 1934.

ter to use the stomatal index ($I = \frac{s}{e-s} \times 100$, where s is the frequency of stomata and e the frequency of epidermal cells in the same unit area) selection of the material to be examined makes it possible to secure figures subject to only slightly greater variation. The cells on the edges of the ridges are difficult to see without special preparation, but Pont[22] in studies on two species of plants did not count the epidermal cells upon the ridges. Frequently, however, it is difficult to distinguish between the cells of the furrows and those of the edges of the ridges, although the latter are usually longer.

By utilizing supplementary characters such as those just mentioned it is possible to identify almost any specimen of *Ephedra* from North America. Table I lists figures which will aid in the determination of vegetative as well as staminate and ovulate material.

The outer layers of cortical cells are chlorophyll-bearing and include numerous air spaces. Starch grains, calcium oxalate crystals and tannin are enclosed within many of these cells. Three systems of fibers are distinguished in this region by Graham[23]: the hypodermal, which underlies the ridges, as hitherto mentioned; the mesocortical, which is scattered through the cortex; and the pericyclic, which is scattered about on the periphery of the stele with the largest fibers abutting the vascular strands. The hypodermal fibers and those of the pericycle which adjoin the vascular bundles are the most constant in numbers and in size. At the nodes this fiber system is interrupted.

Lignified cells and fibers are found in the pith, and a peridermal diaphragm is produced at the base of each internode, which, with the interruption of the fiber system, allows ready fragmentation of the stems.

The stele is an endarch siphonostele with a slight variation in the numbers of bundles. Those species characterized by ternate arrangement of the leaves and bracts have three pairs

[22] Pont in Beih. z. Bot. Centr. **59**: 214–224, *6 figs.* 1939.

[23] Graham in Trans. Roy. Soc. Edinb. **46**: 203–212, *3 pls.* 1909.

TABLE I

COMPARISON OF NORTH AMERICAN EPHEDRAS

	Average length of internode in cm.	Number of leaves or bracts in a whorl	Average angle of branch divergence in degrees	Number of vascular bundles in a stem	Number of hypodermal fiber strands	Number of cells in a cross-section of a fiber strand	Number of stomata per sq. mm.	Ovulate bracts: membranaceous, herbaceous or fleshy	Number of seeds in strobilus	Peduncle of ovulate strobilus: present or absent	Usual number of anthers on antherophore
1. *E. trifurca*	3.6	3	30	12–15	40	28	108	mem.	1–3	ab.	5
2. × *E. intermixta*	2.6	3	35–40	15	36	11	120	mem.	1–3	ab.	4–7
3. *E. Torreyana*	2.4	3	48	12–15	48	4	88	mem.	1–3	ab.	7
4. × *E. arenicola*	3.5	2–3	35	10–12	34	14	50	mem.	1–3	pr.	6
5. *E. funerea*	4.	3	60	12–15	60	5	84	mem.	1–3	ab.	7
6. *E. californica*	3.8	3	45	12–15	36	9	92	mem.	1	ab.	7
7. *E. aspera*	3.	2	35	10	40	10	68	mem.	1	ab.	5
8. *E. fasciculata*	2.5	2	35	10	48	4	72	mem.	1	ab.	6
9. *E. Clokeyi*	3.	2	40	10	50	7	48	mem.	1	ab.	6
10. *E. nevadensis*	2.8	2	45	10	56	7	84	herb.	2	pr.	8
10a. *E. nevadensis* f. *rosea*	2.8	2	42	10	40	9	60	herb.	2	pr.	–
11. *E. viridis*	2.5	2	33	8–10	39	7	52	mem.	2	pr.	7
12. *E. Coryi*	2.5	2	22	8–10	34	12	48	flsh.	2	pr.	7
12a. *E. Coryi* var. *viscida*	3.6	2	28	10	35	16	52	herb.	2	pr.	6
13. *E. antisyphilitica*	2.8	2	48	10	20	5	76	flsh.	1	ab.	6
13a. *E. antisyphilitica* var. *brachycarpa*		2							1		
14. *E. compacta*	2.	2	37	10	12	14	96	flsh.	2	ab.	–
15. *E. pedunculata*	4.	2	52	8–10	18	12	56	flsh.	2	pr.	6

or three groups of three small bundles. In forms with binate arrangement of parts the vascular system consists of two pairs of large bundles alternating with two pairs or with three groups of three small bundles.

The xylem consists of spiral primary elements and secondary tracheids and vessels with bordered pits. These last are modified tracheids, and the oblique end walls have bordered pits larger than those on the lateral walls. These pits enlarge to lose both torus and border and occasionally fuse.[24]

The primary phloem consists of cambiform parenchyma elements and narrow sieve-tubes with oblique plates.

The wood rays are large, uniseriate in young wood, multiseriate in older branches, and consist of storage parenchyma and transformed longitudinal fibers. The pits are small and simple. Depressions in the wood correspond to the positions of the large rays. There is no apparent relation between the position of the rays and that of the leaf traces.

The angle formed by the branches with the stem in any species is relatively constant, although the amount of branching and the length of branches and of internodes are variable within limits for each species and are altered by changes in environmental conditions.

Leaves.—The leaves are small, scale-like, and usually connate. The median and basal portions are thickened, and an abscission layer developed near the base renders the leaf caducous in most species. The leaves are either opposite or ternate and the whorls alternate.

Strobili.—All the North American species are essentially dioecious, but it is often possible to find a plant of any species which bears strobili of both types. I have also seen bisporangiate strobili on otherwise staminate plants of *E. trifurca, E. Torreyana, E. aspera* and *E. Clokeyi.* Bisporangiate strobili were not found on ovulate plants. Apparent sexual differentiation is confined to the peduncles and strobili.

The staminate strobili are compound and borne in pairs or

[24] Jeffrey, The anatomy of woody plants, p. 367. 1917.

whorls at the nodes of the young branches, or rarely terminally. They consist of an axis bearing 2–13 whorls of binately or ternately arranged bracts, all except the lower subtending a vasiform perianth which surrounds a staminal column. Upon this column, or sporangiophore, are borne the three to twelve usually bilocular anthers which may be sessile or stipitate. The column in some species is very variable. In *E. Clokeyi* it may attain a length three times the normal, and in *E. Torreyana* a slender column may bear one uniloculate anther or a branched column may bear up to ten bi- and triloculate anthers. The bract and perianth are more constant in size within the species, and outlines of these and typical columns are figured in plate 27.

The ovulate strobili are solitary or whorled at the nodes of the young branches and may be sessile or long-pedunculate. Three to twenty whorls of membranaceous to fleshy bracts surround the one to four ovules. The ovule is enclosed by two integuments, the inner extending through an opening of the outer to form a tubillus which leads to the pollen chamber at the tip of the ovule. Although the form of the tubillus was used as a character in the delimitation of species by both Meyer and Stapf, it varies somewhat in most of the American species and is not of great value as a diagnostic character. The length of the peduncle, the number, shape, size and texture of the bracts, and the character and numbers of seeds (pl. 27) are the most valuable characters in delimitation of species.

Phylogeny and Geographical Distribution

It is possible to trace a probable course of evolutionary development among the American species of *Ephedra,* but such speculation is of little value unless based upon a thorough knowledge of the entire genus. The apparent differences between species of even separate continents are often so slight that all must be considered in any theorizing upon developmental sequences. The key to the species is artificial, and the entities are grouped only so that the most similar ones are close together.

The distribution maps (pl. 28) are fairly accurate with the exception of Nevada and Mexico, where an insufficient number of collections have been made. The region of greatest specific concentration for North America is in west-central Arizona where seven of the eighteen entities occur.

Acknowledgments

The author is deeply indebted to numerous people whose aid and advice have made the present study possible. For the privileges of studying at the Missouri Botanical Garden and the use of the herbarium and the library the writer expresses his thanks to Dr. G. T. Moore, Director of that institution. Grateful acknowledgment is also due Dr. J. M. Greenman, Curator of the Herbarium, and Miss Nell C. Horner, Librarian and Editor of Publications.

Entire or partial collections of *Ephedra* were borrowed from several institutional and private herbaria, and certain herbaria were visited. To these institutions and individuals the author wishes to express his gratitude. These herbaria are indicated in the text by the following abbreviations:

(BYU) —Brigham Young University.
(Buf) —Buffalo Museum of Science.
(CA) —California Academy of Sciences.
(Clo) —Herbarium of I. W. Clokey.
(F) —Field Museum of Natural History.
(G) —Gray Herbarium of Harvard University.
(I) —Iowa State College.
(M) —Missouri Botanical Garden.
(NMAM)—New Mexico State College of Agriculture and Mechanic Arts.
(P) —Pomona College.
(R) —Rocky Mountain Herbarium of the University of Wyoming.
(S) —Leland Stanford University.
(SD) —San Diego Natural History Museum.
(T) —Agricultural and Mechanical College of Texas.

(TTC) —Texas Technological College.
(UC) —University of California.
(UI) —University of Iowa.
(UNM) —University of New Mexico.
(UW) —University of Wisconsin.
(US) —United States National Herbarium.

TAXONOMY

Ephedra [Tourn.] L., Sp. Pl. **2**: 1040. 1753; Gen. Pl., ed. 5, 462. 1754; C. A. Meyer in Mem. Acad. Imp. Sci. St. Petersburg, VI, Sci. Nat. **5**: 291. 1846; Endlicher, Syn. Conif. 253. 1847; Torr. in Emory, Mil. Reconn. 151. 1848; Torr. in Emory, Rep. U. S. & Mex. Bound. Surv. **2**: 207. 1859; Parl. in DC., Prodr. **16**^{2}: 352. 1868; Wats. in U. S. Geol. Surv. Fortieth Parallel [Bot. King's Exp.] **5**: 328. 1871; Parry in Am. Nat. **9**: 351. 1875; Wats. in Proc. Am. Acad. **14**: 298. 1879; Wats., Bot. Geol. Surv. Calif. **2**: 108. 1880; Wats. in Proc. Am. Acad. **18**: 157. 1883; Stapf in Denkschr. K. Akad. Wiss. Wien **56**^{2}: 1. 1889; Coult. in Contrib. U. S. Nat. Herb. **2**: 552. 1894; Rydb. in Colo. Agr. Exp. Sta. Bull. [Fl. Colo.] 100: 10. 1906; Rose in Contrib. U. S. Nat. Herb. **12**: 261. 1909; Coult. & Nels., Man. Rky. Mt. Bot. 19. 1909; Jepson, Fl. Calif. 65. 1912; Wooton & Standl. in Contrib. U. S. Nat. Herb. **19**: 38. 1915; Goldman in Contrib. U. S. Nat. Herb. **16**: 315. 1916; Rydb., Fl. Rky. Mts. and Adj. Plains, ed. 1, 19. 1918, ed. 2, 19. 1923; Standl. in Contrib. U. S. Nat. Herb. **23**: 63. 1920; Johnston in Univ. Calif. Pub. Bot. **7**: 437. 1922; Abrams, Ill. Fl. Pac. States, 77. 1923; Davidson & Moxley, Fl. So. Calif. 31. 1923; Jepson, Man. Fl. Pl. Calif. 61. 1925; Tidest. in Contrib. U. S. Nat. Herb. **25**: 56. 1925; Rehder, Man. Cult. Trees & Shrubs, 67. 1927; Groff & Clark in Univ. Calif. Pub. Bot. **14**: 247. 1928; George, Supp. aux Mém. Soc. Sci. Nancy **1930**: 29. 1930; Coville & Morton in Jour. Wash. Acad. Sci. **25**: 307. 1935; Jepson, Man. So. Calif. Bot. 19. 1935; Nelson in Am. Jour. Bot. **21**: 573. 1935; Reed in Bull. Torr. Bot. Club **62**: 43. 1935; Reed in Bull. Torr. Bot. Club **63**: 351. 1936; Cory in Rhodora **40**: 216. 1938.

Chaetocladus Senilis [=Nelson] Pinac. 161. 1866.

Erect or clambering, dioecious or rarely monoecious shrubs; branches equisetoid, solitary, or whorled; vascular cylinder an endarch siphonostele; wood rays large, uniseriate in young wood, multiseriate in older branches, composed of storage parenchyma and transformed longitudinal wood fibers; wood containing vessels with oblique terminal walls perforated by numerous pits larger than those on lateral walls, the membranes of these terminal pits lost at an early stage, the pits occasionally fused to form slits; leaves binate or ternate, small, usually united to form a sheath; staminate strobili compound, binately or ternately whorled bracts including a vasiform structure composed of the base of the antherophore upon which are borne the few to many usually biloculate sessile to short-stipitate anthers; ovulate strobili with few to many whorls of binately or ternately arranged membranaceous to fleshy bracts surrounding the one to several ovules, the inner integument extended to form a cylindrical projecting tubillus; two archegonia usually present.

Type species: *Ephedra distachya* L., Sp. Pl. **2**: 1040. 1753.

ARTIFICIAL KEY

A. Leaves and bracts of spikes ternate.
  B. Leaves becoming shredded and gray with age, persistent; terminal buds spinose.
    C. Leaves more than 8 mm. long............................*1. E. trifurca*
    CC. Leaves less than 8 mm. long..........................*2. E. intermixta*
  BB. Leaves remaining firm or falling off with age; terminal buds not spinose.
    D. Seeds less than one-half as wide as long, cream to light brown, rough and angular.
      E. Ovulate bracts as broad as long or broader; east of California.... ....*3. E. Torreyana*
      EE. Ovulate bracts two-thirds as broad as long or less; Death Valley region to Nevada..................................*5. E. funerea*
    DD. Seeds more than one-half as wide as long, brown, smooth and almost spherical..*6. E. californica*
AA. Leaves and bracts of spikes binate, occasionally ternate.
  F. Inner bracts of the ovulate spike membranaceous or herbaceous.
    G. Seeds solitary, or if more than one, light in color.
      H. Seeds almost circular in cross-section.
        I. Seeds smooth, brown to chestnut in color; leaf-bases brown and persistent; stem usually rough..........................*7. E. aspera*

II. Seeds furrowed or scabrous, light brown to gray-green; leaf-bases gray and deciduous; stem usually almost smooth.
J. Seeds more than 9 mm. long.......................*8. E. fasciculata*
JJ. Seeds less than 9 mm. long..........................*9. E. Clokeyi*
HH. Seeds trigonal or tetragonal in cross-section..........*4. E. arenicola*
GG. Seeds paired, brown to almost black.
K. Ovulate spikes sessile or very short-pedunculate; seeds lightly furrowed longitudinally; leaf-bases brown................*11. E. viridis*
KK. Ovulate spikes usually long-pedunculate; seeds usually smooth; leaf-bases gray or brown.
L. Leaf-bases deciduous and gray; seeds about one-half as thick as long; stem not viscid.
M. Seeds more than 5 mm. in length, slightly exserted, chestnut; bracts with a faint trace of pink..............*10. E. nevadensis*
MM. Seeds 5 mm. or less in length, almost included, nearly black; bracts bright pink to rose............*10a. E. nevadensis* f. *rosea*
LL. Leaf-bases persistent and brown; seeds less than one-half as thick as long; stem viscid..............*12a. E. Coryi* var. *viscida*
FF. Inner bracts of the ovulate spike becoming fleshy; eastern Mexico and United States east of Central New Mexico.
N. Seeds solitary.
O. Seed never less than 6 mm. long, less than 3 mm. broad, slightly exserted...................................*13. E. antisyphilitica*
OO. Seed less than 6 mm. long, about 3 mm. broad, included.......... ....*13a. E. antisyphilitica* var. *brachycarpa*
NN. Seeds paired.
P. Bracts red; leaf-bases gray and deciduous.
Q. Low compact shrubs, not clambering; ovulate spikes sessile; anthers not known.............................*14. E. compacta*
QQ. Clambering shrubs; ovulate spikes pedunculate; anthers long-stipitate.......................................*15. E. pedunculata*
PP. Bracts yellow to orange; leaf-bases brown and persistent........ ....*12. E. Coryi*

1. Ephedra trifurca Torr. ex Wats. in U. S. Geol. Surv. Fortieth Parallel [Bot. King's Exp.] **5**: 329. 1871.

E. occidentalis Torr. in Emory, Mil. Reconn. 151. 1848 [in error, evidently intended for *E. americana* Willd.].

E. trifurcus Torr. in Emory, Mil. Reconn. 152. 1848.

E. antisyphilitica Torr. in Emory, Rep. U. S. Mex. Bound. Surv. **2**: 207. 1859, in part.

E. trifaria Parl. in DC., Prodr. **16**^{2}: 359. 1868.

Erect dioecious shrub, 0.5–2 m. high; branches rigid, hard, terete, up to 3.5 mm. thick, solitary or whorled at the nodes, angle of divergence with the main stem about 30 degrees; inter-

nodes 3–9 cm. long; bark of young stems pale green, almost smooth, with numerous small longitudinal furrows, becoming yellow, then gray-green; bark of older stems cinereous, cracked and somewhat irregularly fissured longitudinally; terminal buds 1 cm. long, spinose; leaves ternately whorled, 5–13 mm. long, subspinosely tipped from a dorso-median thickening, connate for one-half to three-fourths their total length; sheath at first membranaceous, later fibrous, shredded and grayish, persistent; staminate spikes solitary or numerous in a whorl at the nodes of the young branches, obovate, 6–9 mm. long, short-pedunculate, peduncles many-scaled, bracts ternate, in 8–12 whorls, obovate, slightly clawed, 3–4 mm. long, 2–3 mm. broad, membranaceous, reddish-brown, the lower whorls empty; perianth almost equaling the subtending bract; staminal column 4–5 mm. long, one-fourth exserted, with 4–5 short-stipitate anthers; ovulate spikes solitary or numerous in a whorl at the nodes of the young branches, obovate, 10–14 mm. long, short- and scaly-pedunculate or sessile, bracts ternate, in 6–9 whorls, orbicular, clawed, 8–12 mm. long, 9–12 mm. broad, translucent except for the reddish-brown center and basal portion, margins entire; fruit solitary or, occasionally, two or three, usually tetragonal, light brown, smooth, 9–14 mm. long, 1.5–3 mm. wide, equaling the bracts; tubillus straight, conspicuously exserted, the twisted ligulate limb 1 mm. long.

Distribution: southwestern Texas and southern New Mexico to California, and adjacent Mexico.

SPECIMENS EXAMINED:

TEXAS: Limpia Canyon, May 1915, *Allen 177* (G, M); in gravel, semidesert foothills, Franklin Mts., Canutillo, El Paso Co., 3 July 1911, *Barlow* (F); sandy places near El Paso, *Bigelow 3* (G); plain, 3 miles east of Casa Piedra, Presidio Co., 21 Feb. 1937, *Cutler 622* (G, M, P, UW); sands west of gap, Dog Canyon, Santiago Mts., Brewster Co., 27 May 1938, *Cutler 1852–1859* (M); along creek bottom, 3 miles southeast of Castolon, Brewster Co., 29 May 1938, *Cutler 1877, 1879, 1881* (M); sandy plain, 8 miles northwest of Presidio, Presidio Co., 31 May 1938, *Cutler 1920* (M); along dry creek, 17 miles north of Shafter, Presidio Co., 1 June 1938, *Cutler 1942, 1943* (M); along railroad, 2 miles west of Marfa, Presidio Co., 1 June 1938, *Cutler 1952* (M); in sand, forming hummocks, 12 miles northeast of El Paso, El Paso Co., 4 June 1938, *Cutler 1980–1982* (M); flats near Van Horn, 12 May 1901, *Eggert* (M); Mt. Livermore, May 1936, *Hinckley 257* (F); El Paso, 17 April 1884, *Jones 3717* (CA, F, NMAM, P); Marathon, 23 April 1930, *Jones*

26403 (M, P); about 5 miles west of Alpine, Brewster Co., 25 April 1931, *McKelvey 1997, 1998* (P); Boquillas, Brewster Co., 20 July 1937, *Marsh 143* (F); gravelly plain, 3 miles west of Mt. Livermore, Davis Mts., alt. 1800 m., 14 June 1931, *Moore & Steyermark 3083* (CA, G, M); gravelly desert, west side of Chisos Mts., alt. 1065 m., Brewster Co., 27 June 1931, *Moore & Steyermark 3287* (CA, G, M); Hueco Tanks, 1 July 1895, *Mulford 187, 187a* (M); low hills near Fort Davis, 7 July 1917, *Munz 1408* (P); rocky open ground, upper Limpia Canyon, Jeff Davis Co., 17 June 1926, *Palmer 30989* (M); Barstow, 18 April 1902, *Tracy & Earle 66* (F, M); Allamore, 23 April 1932, *Whitehouse 8339* (F).

NEW MEXICO: sandy fields, 7 miles north-northeast of Oro Grand, Otero Co., 4 June 1938, *Cutler 1983, 1984* (M); along creek bed, Rhodes Pass, 30 miles east of Engle, 5 June 1938, *Cutler 2019* (M); fields, 3 miles west of Elephant Butte Dam, Sierra Co., 7 June 1938, *Cutler 2068–2074* (M); on creosote-bush desert near San Marcial, 23 Feb. 1934, *Detwiler 21* (F); near Silver City, 3 April 1919, *Eastwood 8192, 8193* (CA); Nutt, 1420 m., Luna Co., 6 Oct. 1919, *Eggleston 16269* (F); along the Gila River and on the mesa above Cliff, Grant Co., 24 Oct. 1919, *Eggleston 16508* (M); "From the region between the Del Norte and the Gila, and the hills bordering the latter river to the desert west of the Colorado," *Emory Exp.* (TYPE, not seen); wash, 3 miles west of Pyramid Peak, alt. 1200 m., Dona Ana Co., 29 Aug. 1930, *Fosberg S3474* (P); Deming, 11 Aug. 1936, *Gaines* (UNM); Socorro, 1880, *Greene* (F); Lordsburg, 9 April 1930, *Jones 25966* (P); Deming, 9 April 1930, *Jones 26402* (M, P); Organ Mts., Las Cruces, Sept. 1931, *Layton* (I); Mangas Springs, 18 miles northwest of Silver City, Grant Co., 26 Sept. 1903, *Metcalfe 811* (M); hillside near Albuquerque, alt. 1200 m., 17 Dec. 1936, *Miers* (UNM); Deming, 31 Aug. 1895, *Mulford 1025* (I, M); dry rocky hills along the Rio Grande near Caballo Dam, 17 miles east of Hillsboro, Sierra Co., 15 June 1938, *Ownbey & Ownbey 1633* (M); desert plain 8 miles northeast of Lordsburg, Hidalgo Co., 19 June 1938, *Ownbey & Ownbey 1647* (M); Dry Canyon, Sacramento Mts., Alamogordo, alt. 1400 m., 9 April 1902, *Rehn & Viereck* (P, R); San Antonio, 1883, *Rusby* (F); mesa west of Agricultural College, 3 May 1906, *Standley 38* (M); mesa, west of Organ Mts., 22 June 1906, *Standley 441* (M); sandy soil, Valverde, 31 July 1846, *Wislizenus 58* (M); mesa, near Las Cruces, 10 May 1892, *Wooton 426* (NMAM); mesa, near Las Cruces, alt. 1250 m., 5 July 1897, *Wooton 96* (G, M, P); mesa, west of the Organ Mts., Dona Ana Co., 22 April 1899, *Wooton* (NMAM); mesa, west of Organ Mts., Dona Ana Co., alt. 1230 m., 19 April 1905, *Wooton* (I, NMAM); Frontera and Donnana, coll. of 1851–52, *Wright 1884* (G, M).

ARIZONA: San Bernardino Valley, alt. 1230 m., Cochise Co., 18 April 1928, *Ballou* (CA, P); mesa, north of Rillito Creek, Pima Co., 16 Jan. 1920, *Bartram 16* (P); Yuma, 3 April 1914, *Carlson* (CA); highway 60, near Globe, 1050 m., Gila Co., 21 April 1935, *Collom 341* (M); Yuma, 22 April 1917, *Eastwood 6348* (CA); canyon, Santa Rita Mts., Tucson, 22 March 1919, *Eastwood 8115* (CA); Bowie, 16 May 1919, *Eastwood 8624* (CA); along road from Packard to Payson, 1 Nov. 1928, *Eastwood 16606* (CA); on the road from Prescott to Phoenix, 11 Nov. 1928, *Eastwood 16608* (CA); Sierra Ancha, 7 May 1929, *Eastwood 16950* (CA); Mazatzal Mts., 12 May 1929, *Eastwood 17169* (CA); on road between Globe and Roosevelt, 24 May 1929, *Eastwood 17447* (CA); Pinal Mts., 18 May 1929, *Eastwood 17526* (CA); on road to Rincon Mts., 19 March 1930, *Eastwood 17805, 17811* (CA, G);

Cochise, Feb. 1927, *Ellis & Ledman* (M); on the mesa, north of the Santa Rita Mts., 28 Sept. 1880, *Engelmann* (M); Roadside Mine, Pima Co., 3 April 1932, *Fosberg* (M, P); Douglas, 22 May 1907, *Goodding 2268* (M); desert "prairie," north of Tucson, 4 April 1913, *Greenman & Greenman 74* (M); small range reservation near Tucson, 13 March to 23 April 1903, *Griffiths 3534* (M); Congress Junction, alt. 900 m., 2 May 1903, *Jones* (P); Oracle, alt. 1400 m., 28 Aug. 1903, *Jones* (P); Rodeo, 8 April 1930, *Jones 26400* (M, P); Stein's, 6 May 1930, *Jones 25965* (CA, M, P); Benson, 6 April 1930, *Jones 26401* (P); Sulphur Springs Valley, 18 May 1921, *W. W. Jones 434* (G); mesas, near Tucson, spring 1907, *Lloyd* (F, G); Yuma desert at Monument 204, International Boundary, 17 March 1894, *Mearns 2826* (S); sand dunes, south of Wellton, Gila Desert, Jan. 1916, *Monnet 1110* (CA); rocky washes, 25 miles west of Casa Grande City, 22 March 1935, *Nelson & Nelson 1259* (M, R); sandy Yuma desert near U.S.-Mexican boundary, 26 March 1935, *Nelson & Nelson 1290* (M, R); near Cochise, 24 April 1935, *Nelson & Nelson 1619* (M); Tucson, 2 Feb. 1926, *Nuttall* (CA, F, P); Mohave Agency, 1 April 1876, *Palmer 523½* (G, M); Yuma, 20 March 1881, *Parish & Parish 753* (F, G); Tucson, April 1884, *Parish* (M); Lowell, May 1884, *Parish* (I); Sulphur Springs Valley, 13 April 1894, *Price* (S); mesas, 29 April 1881, *Pringle* (F, G, M); mesa, near Tucson, 2 April 1883, *Pringle* (F); mesa, near Tucson, 21 April 1884, *Pringle* (F); Metcalf, near Clifton, *Reynolds* (CA); wash, west of Desert Lab., Tucson, 22 June 1908, *Sherff* (F); mesas, near Tucson, 8 April 1917, *Shreve 5158* (G); 5 miles west of Rodeo, Cochise Co., 30 April 1933, *Shreve 6282* (F); Gila, June 1852, *Thurber 681* (G); in sand, 7 miles south of Parker on the Bouse road, Yuma Co., 14 April 1922, *Wiegand & Upton 2979* (F); flats of Desert Lab., Tucson, 15 March 1933, *Wiggins 6508* (P); 42 miles northeast of Douglas on road to Rodeo, alt. 1350 m., 7 July 1928, *Wolf 2555* (CA, G, P).

CALIFORNIA: near Salton Sea, 6 March 1922, *Campbell* (CA, P); sand hills, Yuma-El Centro road, Imperial Co., 19 April 1928, *Ferris 7128* (P); Yaqui Well, Colorado Desert, 21 Jan. 1926, *Jones* (P); Imperial Co., near Arizona, 13 March 1920, *Kline* (UW); sand dunes between El Centro, Imperial Co., and Yuma, Arizona, 25 March 1936, *MacFadden 14476* (CA); Laguna Station, 6 May 1894, *Mearns 2937* (S); under overhanging rocks, foot of Mountain Springs Grade, Imperial Co., 23 Feb. 1924, *Munz 7823* (G, P); Colorado desert near Yuma, 27 Dec. 1880, *Parry* (I, M); Agua Caliente, April 1882, *Parry* (M); sand dunes, west of Fort Yuma, Imperial Co., 15 April 1927, *Peirson 7193* (P); sandy soil, Colorado Desert, 12 miles northwest of Westmorland, below sea-level, Imperial Co., 12 March 1931, *Wolf 1870, 1871* (CA).

MEXICO:

COAHUILA: Del Carmen Mts., 29 Aug. 1936, *Marsh 694* (F).

CHIHUAHUA: San Diego, alt. 1830 m., 10 April 1891, *Hartman 642* (G, US); Sierra Madre, 21 June–29 July 1899, *Nelson 6014* (US); vicinity of Chihuahua, about 1300 m., 8–27 April 1908, *Palmer 68* (F, G, M, US); vicinity of Chihuahua, about 1300 m., 1–21 May 1908, *Palmer 172* (US); Chihuahua, 1885, *Pringle 88* (G); mesas, near Chihuahua, 7 April 1886, *Pringle 868* (F, US); mesas, Chihuahua, 20 May 1887, *Pringle 1589* (F); 11 May 1899, *Rose & Hough 4928* (US); Sta. Eulalia plains, 13 April 1885, *Wilkinson 117* (I, US), in part; Sta. Eulalia plains, 2 April 1886, *Wilkinson 120* (I, US).

SONORA: coast of Gulf of California near upper end, 1910, *Lumholtz 24* (G); Colorado River at Colonia Diaz, 24 March 1894, *Mearns 417* (US); Lower Colorado, 1869, *Palmer* (US).

BAJA CALIFORNIA: Gardner's Laguna, 27 April 1894, *Mearns & Schoenfeldt 2916* (S).

E. trifurca is easily recognized by the yellowed and spinosely-tipped branches and the frayed but persistent leaves of the older stems. The species is very constant throughout its entire range.

2. × **Ephedra intermixta** Cutler,[25] n. hyb.

(= Ephedra trifurca × Torreyana).

Erect dioecious shrub, 0.5–1.5 m. high; branches rigid, solid, terete, up to 3.5 mm. thick, solitary or whorled at the nodes, angle of divergence 35–40 degrees; internodes 1–5 cm. long; young stems pale green, smooth and glaucous, with numerous small longitudinal furrows, becoming yellowed; bark cinereous, cracked and fissured; terminal buds spinose to obtuse-conical; leaves ternate, 3–6 mm. long, acutely tipped from a dorso-median thickening, connate for three-fourths their length at first, soon splitting; sheath membranaceous, later fissured; staminate spikes at the nodes of the young branches, ovate, 3–7 mm. long, sessile or short-pedunculate, bracts ternate, in 3–7 whorls, obovate, 2–3 mm. long, 2 mm. broad, mem-

[25] × **Ephedra intermixta** Cutler, hyb. nov.; frutex erectus, dioiceus, 0.5–1.5 m. altus; ramulis rigidis, solidis, teretibus, usque ad 3.5 mm. in diametro, ad nodos solitariis vel verticillatis, angulo declinationis circiter 35–40°; internodiis 1–5 cm. longis; caulibus juventate pallide viridibus, laevibus et glaucis, tenuissime striatis, deinde lutescentibus; rhytidoma cinerea, rimosa, sulcata; gemmis terminalibus pungentibus vel conicis; foliis ternatis, 3–6 mm. longis, ad apicem pungentibus ex dorso-medio crassificatione, primo ad ¾ longitudinis connatis, deinde diffisis; vagina membranacea, deinde corruta; spicis stamineis solitariis vel multis ad nodos ramulorum novorum, ovatis, 3–7 mm. longis, sessilibus vel brevi-pedunculatis, bracteis ternatis, in 3–7 verticillis, obovatis, 2–3 mm. longis, 2 mm. latis, membranaceis, pallide luteis vel pallide fulvis, verticillis inferioribus vacuis; perianthis bracteas subtendentes subaequantibus; columna staminalis 2–5 mm. longa, ½ exserta, 4–7 antheris brevi-stipitatis; spicis femineis solitariis vel multis ad nodos ramulorum novorum, obovatis, 4–7 mm. longis, sessilibus vel brevi-pedunculatis, bracteis ternatis, in verticillis 5–7, suborbicularibus, unguiculatis, marginibus hyalinis, erosis, 4–7 mm. longis, 4–6 mm. latis, membranaceis, pallide luteis; seminibus plerumque solitariis, tri- aut tetragonatis, pallide fulvis, laevibus, 4–6 mm. longis; tubillo recto, multo exserto, limbo ligulato contorto.

branaceous, light yellow to light brown, the lower whorls empty; perianth almost equaling the subtending bract; staminal column 2–5 mm. long, one-half exserted, with 4–7 short-stipitate anthers; ovulate spikes solitary or numerous at the nodes of the young branches, obovate, 4–7 mm. long, sessile or short pedunculate, bracts ternate, in 5–7 whorls, suborbicular, unguiculate, hyaline margins erose, 4–7 mm. long, 4–6 mm. broad, membranaceous, light yellow; seed usually solitary, tri- or tetragonal, light brown, smooth, 4–6 mm. long; tubillus straight, conspicuously exserted, the ligulate limb contorted.

Specimens examined:

New Mexico: creek bed, Rhodes Pass 30 miles east of Engle, 5 June 1938, *Cutler 2020, 2021* (G, M, US); fields, 3 miles west of Elephant Butte Dam, Sierra Co., 7 June 1938, *Cutler 2075* (G, M type, T, US), *2078* (G, M, T, US).

While making field studies several cases of possible hybridization were observed. Specimens intermediate between *E. trifurca* and *E. Torreyana* were collected both in sandy washes and creek beds, the usual habitat of *E. trifurca,* and in gravelly and sandy fields, the habitat of *E. Torreyana.* The preference of stock for the latter and for *E. intermixta* aids in the field of identification of these two. A comparison with the parent species follows:

E. trifurca	× *E. intermixta*	*E. Torreyana*
Scarcely ever eaten by stock.	Eaten by stock.	Eaten by stock.
Numerous branches at a node.	Numerous to few at a node.	Few branches at a node.
Angle of branch-divergence about 30°.	Angle of branch-divergence about 35–40°.	Angle of branch-divergence about 48°.
Average internode 3.6 cm.	Average internode 2.6 cm.	Average internode 2.4 cm.
Leaves up to 10 mm. long.	Leaves up to 6 mm. long.	Leaves up to 3.5 mm. long.
Bracts usually brown, margins entire.	Bracts from brown and entire to yellow and erose.	Bracts usually yellow, margins erose.
Seeds smooth and light brown.	Seeds smooth and light brown.	Seeds scabrous and light yellow.

3. **Ephedra Torreyana** Watson in Proc. Am. Acad. **14:** 299. 1879.

E. trifurca Parry in Am. Nat. **9:** 351. 1875.

E. antisyphilitica f. *monstrosa* Torr. ex Stapf in Denkschr. K. Akad. Wiss. Wien **56**[2]: 43. 1889.

Erect dioecious shrub, 0.25–1 m. high; branches rigid, hard, terete, up to 3.5 mm. thick, solitary or whorled at the nodes, angle of divergence about 48°; internodes 2–5 cm. long; young stems pale blue-green, glaucous, almost smooth with many small longitudinal furrows, becoming gray; bark of older stems cinereous, cracked and irregularly fissured; terminal buds less than 4 mm. long, conical but not spinose; leaves ternately whorled, 2–5 mm. long, obtusely, occasionally acutely, pointed from a brownish-green dorso-median thickening, connate for one- to two-thirds their total length, but later spreading and recurved; sheath at first membranaceous, later fissured, thickened and grayed, subpersistent; staminate spikes solitary to four in a whorl at the nodes of the young branches, ovate, 6–8 mm. long, sessile; bracts ternate, in 6–9 whorls, ovate, slightly clawed, 2–3.5 mm. long, 2-3 mm. broad, membranaceous, cream-coloured to pale yellow, the lower whorls empty; perianth exceeding the subtending bract; staminal column 2.5–4 mm. long, one-fourth to one-half exserted, with 5–8 sessile or short-stipitate anthers; ovulate spikes solitary or several in a whorl at the nodes of the young branches, ovate, 9–13 mm. long, sessile, bracts ternate, in 5–6 whorls, obovate, clawed, 6–9 mm. long, 6–10 mm. broad, hyaline except for the orange-yellow to greenish-yellow center and basal portion, margins minutely toothed, undulate; seed solitary or two, occasionally three, trigonal or tetragonal, light brown to yellow-green, scabrous, 7–10 mm. long, 1.6–3 mm. wide, equaling or slightly exceeding the bracts; tubillus straight, conspicuously exserted, the contorted ligulate limb 1 mm. long.

Distribution: western Colorado to western Texas and westward to northern Arizona and Nevada.

SPECIMENS EXAMINED:

TEXAS: cottonwoods near El Paso, *Bigelow 4* (G, M); 11.15 miles southwest of Big Springs, Howard Co., 18 April 1930 *Cory 2829* (P); dry steep calcium breaks of Palo Duro Canyon, Randall Co., 31 July 1934, *Goodman 2230* (M); dry rocky slopes of Palo Duro Canyon, Randall Co., 3 June 1918, *Palmer 13873* (M, UW); dry rocky slopes, Channing, Hartley Co., 19 June 1918, *Palmer 14155* (M, UW);

Frontera, 1852, *Parry* (M); sandy hills near Frontera, 26 April 1851, ***Wright 1883*** (G TYPE, M) in part.

COLORADO: Deer Run, region of the Gunnison Watershed, alt. 1430 m., 25 Aug. 1901, *Baker 921* (G, M); Grand Junction, May 1892, *Eastwood* (C); Grand Junction, alt. 1370 m., 21 June 1894, *Jones 5468* (F, M, P); Grand Junction, alt. 1350 m., 9 May 1895, *Jones* (P); Grand Junction, alt. 1350 m., 22 May 1895, *Jones* (P); dry hillside, alt. 1760 m., 7 June 1913, *Payson 108* (F, G, M); dry hillside, alt. 1650 m., Naturita, 19 May 1914, *Payson 319* (F, G, I, M); dry rocky hillside, alt. 1650 m., Naturita, 26 May 1914, *Payson 353* (F, G, I, M); shale hills, Ridgeway, 17 June 1924, *Payson & Payson 3833* (G, M); clay to sandy hillside near the Gunnison River, 6 miles west of Delta, Delta Co., 27 Aug. 1937, *Rollins 1975* (G, M).

NEW MEXICO: San Ysidro, 1700 ft., 9 Feb. 1927, *Arsène 19034* (F); Carlsbad, 1 May 1929, *Benke 5022* (F); highlands, Albuquerque, 23 March 1918, *Collins* (G); Pena Blanca, alt. 1600 m., 21 May 1930, *Curtin 108* (F); fields and along railroad tracks, 3 miles north of Escondida, Otero Co., 4 June 1938, *Cutler 1987, 1988, 1990–1997* (M); White Sands, 13 miles w. of Tularosa, Otero Co., 5 June 1938, *Cutler 2004–2015* (M); Jornada del Muerto, 4 miles east of Engle, Sierra Co., 6 June 1938, *Cutler 2049–2053* (M); 7 miles west of Engle, Sierra Co., 7 June 1938, *Cutler 2061, 2062* (M); in fields, 3 miles west of Elephant Butte Dam, Sierra Co., 7 June 1938, *Cutler 2076, 2077, 2079* (M); Farmington, 8 June 1899, *Diehl* (P); on soft "Santa Fe" gravels, San Juan, west side of Rio Grande, Rio Arriba Co., 23 June 1932, *Godwin* (G); Red Valley, on Cuba-San Ysidro road, 7 July 1932, *Goodwin* (G); banks of the Rio Grande River, 19 miles west of Santa Fe, alt. 1650 m., 31 May 1897, *Heller & Heller 3623* (M); Albuquerque, 14 April 1884, *Jones* (P); Rincon, 30 May 1884, *Jones* (P); Organ Pass, 3 May 1930, *Jones* (P); sand dunes west of Alamogordo, 3 May 1930, *Jones 25962, 25964m* (CA, M, P); mesa about two miles east of Albuquerque, alt. 1520 m., 1915, *Kammerer 5* (M); desert hills west of valley, Santa Cruz, Santa Fe Co., 30 June 1936, *Marcelline 1840* (F); sand hills along Cuba Road, near Bloomfield, San Juan Co., 5 July 1929, *Mathias 613, 614* (G, M, P); Santa Fe, June 1874, *Rothrock 80* (F, G); White Sands, Dona Ana Co., 16 July 1897, *Wooton 568* (M); mesa west of the Organ Mts., near Little Mt., Dona Ana Co., 11 May 1902, *Wooton* (NMAM); San Andreas Mts., Jan. 1907, *Wooton* (NMAM); plains 35 miles south of Torrance, alt. 1830 m., 10 Aug. 1909, *Wooton* (NMAM); coll. of 1851-2, *Wright 1882* (M) in part.

ARIZONA: sandy and rocky soil of mesa, Lee's Ferry, 6 July 1927, *Cottam 2611* (BYU); rough hills, Fort Whipple, Sept. 1865, *Coues & Palmer 570* (M); on sands and among flat rocks of mesa 5 miles west of Rock Point, Apache Co., 15 June 1938, *Cutler 2198, 2199* (M); sands, 5 miles south of Dennehotso, Apache Co., 15 June 1938, *Cutler 2211–2213, 2215, 2220* (M); bluffs, edge of Painted Desert, 20 Oct. 1928, *Eastwood 15720* (CA); between Tuba City and Tonalea, Coconino Co., 10 Sept. 1938, *Eastwood & Howell* (CA); Bright Angel Trail, Grand Canyon, 24 May 1903, *Grant* (S); rocky soil near Cameron, alt. 1520 m., 7 June 1922, *Hanson A166* (F, M); Holbrook, May 1900, *Hough* (F, G); Yucca, 13 April 1884, *Jones* (P); Pierce's Ferry, 426 m., 19 April 1894, *Jones 5077as* (P); Bonelli's Ferry, 800 ft., 13 April 1903, *Jones* (P); between Holbrook and Snowflake, 19 May 1931, *McKelvey 2287, 2288* (P); desert plain between Flagstaff and Holbrook, 26 May 1935, *Nelson & Nelson 2136* (M); 12 miles northeast of Tuba City, alt. 1600 m., 3 June 1935, *Peebles & Fulton 11874* (CA); Monument Valley, alt. 1600 m., Navajo Co., 4

June 1935, *Peebles & Fulton 11940* (P); Grand Falls of the Little Colorado River, Coconino Co., *Whiting 756* (UNM); open prairie, Flagstaff road, alt. 1600 m., 5 miles west of Winslow, Coconino Co., 22 May 1922, *Wiegand & Upton 2977* (F).

UTAH: dry hills, Green River, alt. 1380 m., Emery Co., 6 June 1927, *Cottam 2077* (BYU); dry sandy hillside, 10 miles north of Moab, Grand Co., 8 May 1935, *Cottam 6843* (BYU); on sand and gravel, Copper Canyon, 7 miles northwest of Oljato Post, San Juan Co., 16 June 1938, *Cutler 2232, 2245, 2261, 2262* (M); sand flat, San Juan Canyon, 2 miles southwest of Mexican Hat, San Juan Co., 20 June 1938, *Cutler 2320* (M); hills above Comb Wash, 8 miles west of Bluff, San Juan Co., 21 June 1938, *Cutler 2327* (M); 10 miles north of Bluff, San Juan Co., 21 June 1938, *Cutler 2342* (M); Snake Creek, San Juan Co., 15 Sept. 1938, *Eastwood & Howell 6704* (CA); dry hillside, red sandstone ledges, north of St. George, 6 April 1935, *Galway* (BYU); Santa Clara Creek, 20 May 1902, *Goodding 677a* (M); west of Green River, between river and quarry ledge, 20 miles south of Vernal, alt. 1430 m., Uintah Co., 19 June 1931, *Graham 6123* (M); flat above quarry ledge, west side of Green River, 20 miles south of Vernal, alt. 1460 m., 20 June 1931, *Graham 6171* (M); on rocky south slope of Leland Bench, just north of Pariette Creek, alt. 1520 m., Uintah Co., 13 May 1935, *Graham 8840* (F, M); shale breaks, east side of Willow Creek, about 5 miles north of mouth of Agency Draw, alt. 1680 m., Uintah Co., 22 May 1935, *Graham 8933* (M); red hill north of St. George, 8 May 1935, *Hall* (BYU); dry sandy hills, Sugar Loaf Mt., St. George, Washington Co., 15 May 1932, *Harrison 301* (BYU, M); dry sandy wash, Dirty-Devil River canyon, alt. 2115 m., Fruita, Wayne Co., 6 April 1934, *Harrison 7398* (BYU, M); near Lower Crossing, 9 July 1883, *Jones* (P); Green River, 9 May 1890, *Jones* (P); red sand, St. George, alt. 900 m., 26 April 1894, *Jones 5110aq* (P); San Rafael Swell, 28 May 1914, *Jones* (S); southern Utah, 1874, *Parry 250* (G, M); shale outcrops near Willow Creek, 22 miles south of Ouray, Uintah Basin, Uintah Co., alt. 1825 m., 16 June 1937, *Rollins 1719* (G); Granite Creek at foot of the Henry Mts., alt. 1520 m., 5 July 1930, *Stanton 331* (BYU); streamside-washes, Crescent Creek, Henry Mts., alt. 1825 m., 15 July 1930, *Stanton 437* (BYU); slopes and mesas west of St. George, 5 May 1919, *Tidestrom 9300* (G, M).

NEVADA: 5 miles northwest of Las Vegas, 10 May 1938, *Barkley 3232* (M); limestone ledges south of Indian Springs, 1250 m., Clark Co., 12 May 1938, *Clokey 7816* (Clo, M); open hillsides, Dry Lake, 17 April 1905, *Goodding 2234a* (G, M, P); red sand, St. Joe, alt. 425 m., 7 April 1894, *Jones 5029af, 5029ag* (P); Moapa, alt. 425 m., 27 April 1904, *Jones* (P); Amargosa Desert, alt. 1215 m., 27 April 1907, *Jones* (P); Moapa, alt. 517 m., 12 May 1905, *Kennedy* (M); rocky hillside 6 miles north of Alamo, Lincoln Co., 1934, *Maguire, Maguire & Maguire 4715* (M); dry rocky slopes, vicinity public camp, Valley of Fire, Clark Co., 5 April 1934, *Maguire, Maguire & Maguire 4722* (M).

MEXICO:

CHIHUAHUA: near Ojo de Vaca, May 1851, *Thurber 304* (G).

Ephedra Torreyana is not as constant throughout its range as *E. trifurca*. Specimens from St. George, Utah, and to the northwest, differ in having the ovulate bracts brighter yellow, more crenulate and more undulate.

4. × **Ephedra arenicola** Cutler,[26] n. hyb.
(= *Ephedra Torreyana* × *Coryi* var. *viscida* Cutler).

Dioecious shrub, 0.25–1 m. high; branches flexuous, terete, up to 3 mm. thick, opposite or whorled at the nodes, angle of divergence about 35 degrees; internodes 2–5.5 cm. long; young stems green, viscid, slightly rough, with numerous small longitudinal furrows, becoming yellowed; bark cinereous, cracked and fissured; terminal buds subuliform; leaves binate or ternate, 2–6 mm. long, obtusely to setaceously tipped from a dorso-median thickening, connate for two-thirds their length at first, later splitting; staminate specimens not seen; ovulate spikes solitary to many at the nodes of the young branches, peduncles 5–50 mm. long, bracts binate, in 4–6 whorls, slightly unguiculate, narrowly elliptic, 3–8 mm. long, 2–5 mm. broad, membranaceous, margins hyaline and erose; seeds paired, one frequently aborted, scabrous, light brown to light yellow, 4–7 mm. long, almost equaling the bracts; tubillus straight to somewhat curved, slightly exserted, the ligulate limb contorted.

SPECIMENS EXAMINED:

ARIZONA: sands, 5 miles south of Dennehotso, Apache Co., 15 June 1938, *Cutler 2217* (G, M, T, US), *2221* (G, M TYPE, T, US).

Among typical *E. Coryi* var. *viscida* growing upon loose sands was found a hybrid with *E. Torreyana* which grows near by on slightly more stable and rocky areas. A comparison of the hybrid with the parent plants follows:

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[26] × **Ephedra arenicola** Cutler, hyb. nov.; frutex dioiceus, 0.25–1 m. altus; ramulis flexuosis, teretibus, usque ad 3 mm. in diametro, ad nodos oppositis vel verticillatis, angulo declinationis circiter 35°; internodiis 2–5.5 cm. longis; caulibus juventate viridibus, viscidis, parce scabris, tenuissime striatis, deinde lutescentibus; rhytidoma cinerea, rimosa, sulcata; gemmis terminalibus subulatis; foliis binis vel ternatis, 2–6 mm. longis, ad apicem obtusis vel pungentibus ex dorso-medio crassificatione, primo ad ⅔ longitudinis connatis, deinde diffisis; spicis stamineis mihi ignotis; spicis femineis solitariis vel multis ad nodos ramulorum novorum, pedunculis 5–50 mm. longis, bracteis oppositis, in verticillis 4–6, parce unguiculatis, anguste ellipticis, 3–8 mm. longis, 2–5 mm. latis, membranaceis, marginibus hyalinis erosis; seminibus binis, quorum uno saepe abortivo, scabriusculis, pallide fulvis vel pallide luteis, 4–7 mm. longis, bracteas subaequantibus; tubillo recto vel parce curvato, leviter exserto, limbo ligulato contorto.

E. Torreyana	*E. arenicola*	*E. Coryi* var. *viscida*
Average internode 2.4 cm.	Average internode 3.5 cm.	Average internode 3.6 cm.
Angle of branch-divergence about 48°.	Angle of branch-divergence about 35°.	Angle of branch-divergence about 28°.
Stem not viscid.	Stem viscid.	Stem viscid.
Leaves ternate.	Leaves binate and ternate.	Leaves binate.
Leaves short, obtuse, persistent.	Leaves long, setaceous, persistent.	Leaves long, setaceous, deciduous.
Ovulate strobilus sessile.	Ovulate strobilus long-peduncled.	Ovulate strobilus long-peduncled.
Bracts ternate.	Bracts binate.	Bracts binate.
Bracts dry, membranaceous, clawed.	Bracts dry, membranaceous, slightly clawed.	Bracts succulent, connate at base.
Seeds light and scabrous.	Seeds light and scabrous.	Seeds dark and smooth.

5. **Ephedra funerea** Coville & Morton in Jour. Wash. Acad. Sci. **25**: 307. 1935.

Erect dioecious shrub, 0.25–1.5 m. high; branches stiff, hard, terete, up to 3.5 mm. thick, solitary or several, usually three, at the nodes, angle of divergence about 60 degrees; internodes 2–6 cm. long; young stems pale gray-green, glaucous, slightly roughened, glandulose, with many small longitudinal furrows, later gray; bark of older stems cinereous, slightly cracked and fissured; terminal buds 1–4 mm. long, acute-conical, not spinose; leaves ternately whorled, 3–6 mm. long, acutely pointed from a dorso-median thickening, at first connate for one-half to two-thirds their total length, later splitting along the margins and spreading slightly, persistent; staminate spikes one, two or three, at the nodes of the young branches, elongate-elliptic, 5–8 mm. long, sessile or borne on very short scaly-bracted peduncles, bracts ternate, in 6–9 whorls, ovate, short-clawed, 3–4 mm. long, 2–3 mm. broad, membranaceous, yellowish, the lower whorl empty; perianth equaling the subtending bracts; staminal column 3–4 mm. long, one-third exserted, with 4–7 sessile or very short-stipitate anthers; ovulate spikes one, two or three, at the nodes of the young branches, lanceolate-obovate, 8–13 mm. long, on short scaly-bracted peduncles, or sessile, bracts ternate, in 6–9 whorls, elongate-

obovate, broadly clawed, 4–8 mm. long, 3–5 mm. broad, yellow-translucent except for the green thickened central portion, margins slightly dentate; seed solitary, or rarely, two or three, tetragonal, pale green to light brown, smooth to scabrous, 6–9 mm. long, 2–3.5 mm. wide, equaling or barely exceeding the bracts; tubillus straight, exserted, the truncate tip slightly contorted.

Distribution: Death Valley region, California, to Nevada.

SPECIMENS EXAMINED:

CALIFORNIA, DEATH VALLEY REGION: mountain side below Dante's View, 1500 m., 7 April 1935, *Clokey & Templeton 5675, 5676* (Clo, M); Furnace Creek Canyon, alt. 870 m., 16 April 1931, *Coville & Gilman 19* (US); Furnace Creek Canyon, alt. 940 m., 18 April 1931, *Coville & Gilman 108* (US); Boundary Canyon, alt. 1065 m., 24 April 1932, *Coville & Gilman 407–410* (US); Furnace Creek Canyon, near the old town of Ryan, alt. 900 m., 25 April 1932, *Coville & Gilman 444, 445* (US); Furnace Creek Canyon, on the Ryan-Shoshone road, alt. 980 m., 26 April 1932, *Coville & Gilman 447* (US TYPE); Furnace Creek Canyon, junction of the Dante's View road with the Ryan-Shoshone road, alt. 1020 m., 26 April 1932, *Coville & Gilman 448* (US); Warm Springs Canyon, Panamint Mts., about a mile above Warm Springs, alt. 790 m., 30 April 1932, *Coville & Gilman 502, 502A* (US); Furnace Creek Wash, 6 April 1928, *Craig 919* (M); hillside, Ryan, 17–24 March 1924, *Ferris, Scott & Bacigalupi 4036* (S); rocky hillside 1 mile south of Ryan, 16 April 1932, *Hitchcock 12329* (M, P, US); sandy open, 2 miles east of Bradbury Well, Black Mts., 2 April 1928, *Howell 3643* (CA); Funereal Mts., alt. 1200 m., 10 April 1907, *Jones* (P).

NEVADA: gravelly hills, Arden-Mountain Springs, mile 11, alt. 1100 m., Charleston Mts., Clark Co., 22 April 1939, *Clokey 8225* (Clo, M).

6. Ephedra californica Watson in Proc. Am. Acad. **14**: 300. 1879.

Erect or spreading dioecious shrub, 0.3–1 m. high; branches semiflexible to rigid, hard, terete, up to 4 mm. thick, solitary or whorled at the nodes, angle of divergence about 45 degrees; internodes 3–6 cm. long; young stems yellow-green, glaucous, almost smooth, with numerous longitudinal furrows, becoming yellow, then yellow-brown; bark of older stems gray-brown, cracked and irregularly fissured; terminal buds 2–3 mm. long, acute, conical; leaves ternately whorled, 2–6 mm. long, obtusely to acutely tipped from a green-brown dorso-median thickening, connate from one-half to three-fourths their total length; sheath at first membranaceous, later thickened, becoming

brown, hard and fibrous, splitting and recurving, subpersistent; staminate spike solitary or several in a whorl at the nodes of the young branches, ovate, 6–7.5 mm. long, short-pedunculate, peduncles many-scaled, bracts ternate, in 8–12 whorls, ovate, slightly united at the base, 2.5–3 mm. long and broad, membranaceous, light orange-yellow except for the hyaline margins, the lower whorls empty; perianth equaling or slightly exceeding the subtending bract; staminal column 3–5 mm. long, one-third exserted, with 3–7 sessile or short-stipitate anthers; ovulate spikes solitary or several in a whorl at the nodes of the young branches, ovate, 7–10 mm. long, very short- and scaly-pedunculate, bracts ternate, in 4–6 whorls, orbicular, very slightly unguiculate, 5–7 mm. long, 5–10 mm. broad, pale yellow-translucent except for the orange- or green-yellow center and basal portions, margins entire; seed solitary, rarely two, nearly globular but indistinctly tetragonal, light to dark brown or chestnut, smooth, 7–9 mm. in diameter, equaling or slightly exceeding the bracts; tubillus straight, barely exserted, with a short ligulate, scarcely contorted limb.

Distribution: southern California and adjacent Arizona, and northern Baja California.

SPECIMENS EXAMINED:

ARIZONA: Kingman-Yucca road, Mohave Co., 26 March 1927, *Braem* (S).

CALIFORNIA: Palm Springs, Riverside Co., 6 April 1903, *Abrams 3204* (CA, P); hills near Tia Juana, 14 May 1903, *Abrams 3489* (G, M, P, S); dry hillsides near Campo, San Diego Co., 24 May 1903, *Abrams 3600* (G, M, P, S); Jacumba, 31 May 1903, *Abrams 3675* in part (S); Palm Springs, 17 April 1926, *Atsalt* (M); granite soil, Mt. Breckenridge, alt. 900 m., Kern Co., 23 April 1932, *Benson 3358* (S); North Island, 7 May 1904, *Chandler 5165* (S); Coronado, alt. 3 m., near San Diego, June 1893, *Cleveland* (S); mouth of Mosaic Canyon, sea level, Death Valley region, 6 April 1935, *Clokey & Templeton 5784* (Clo, M); field at Coronado, 26 Dec. 1908, *Dudley* (S); Caliente Mts., back of Painted Rock, San Luis Obispo Co., June 1927, *Dudley* (CA); near Ozena P. O., Ventura Co., May 1936, *Dudley* (CA); North Coronado, San Diego Co., 7 April 1913, *Eastwood 2570, 2571* (CA); San Felipe Canyon, Colorado Desert, San Diego Co., 14 April 1913, *Eastwood 2782* (CA); Grapevine Creek, Colorado Desert, San Diego Co., 14 April 1913, *Eastwood 2808* (CA); Tia Juana, San Diego Co., 24 April 1913, *Eastwood 2911* (CA); Palm Springs, San Bernardino Co., 30 April 1913, *Eastwood 3082* (CA); Warren's ranch, Campo, San Diego Co., 22 April 1920, *Eastwood 9412, 9413* (CA); Coalinga, Fresno Co., 31 March 1926, *Eastwood 13453* (CA); near Mountain Spring, San Diego Co., 25 April 1932, *Eastwood 18641* (CA); Morongo Valley, San Bernardino Co., 28

May 1932, *Eastwood 18687* (CA); on road from Barstow to Las Vegas, San Bernardino Co., 30 April 1932, *Eastwood 18766* (CA); on road from Barstow to Las Vegas, San Bernardino Co., 30 April 1932, *Eastwood 18798* (CA); Griswold Creek, southeast of Panoche, San Benito Co., 3 May 1937, *Eastwood & Howell 4273, 4274* (CA); Little Panoche Pass, San Benito Co., 19 April 1938, *Eastwood & Howell 5129, 5130* (CA); Jacumba Springs, San Diego Co., 11–16 April 1924, *Eggleston 19706* (CA, P); sand beach which forms the San Diego Bay, opposite town, 4 Nov. 1880, *Engelmann* (M); Whitewater Desert near San Gorgonio Pass, 10 Nov. 1880, *Engelmann* (M); Whitewater Pass, near Palm Springs, March 1927; *Epling* (M); Box Canyon, San Diego Co., 4 April 1932, *Epling & Robison* (M, CA, S); Cuyama Valley, Kern Co., 13 April 1935, *Esau* (CA); head of Cuyama Valley near Kern Co. line, San Luis Obispo Co., 30 March 1935, *Ferris 9140* (CA, S); in wash near Little Panoche Creek, 25 miles from South Dos Palos on the Panoche road, Fresno Co., 7 April 1938, *Ferris 6953* (P, S); Mohave River bed at Daggett, San Bernardino Co., 14 June 1930, *Ferris 8012* (S); pass in Sheep Hole Mts. between Amboy and Dale P. O., San Bernardino Co., 25 April 1932, *Ferris & Bacigalupi 8128* (P, S); wash, west end of Sheep Hole Mts., San Bernardino Co., 24 April 1932, *Fosberg 7951* (M); Round Granite Hill near the Narrows, San Diego Co., 14 Nov. 1935, *Gander 2955* (SD); San Luis Rey Valley, near Rancho San Luis Rey, San Diego Co., 21 Jan. 1937, *Gander 3028* (SD); along Coyote Creek, about 3 miles southeast of Lone Palm, north end of Borego Valley, San Diego Co., 6 March 1935, *Gander 13454* (SD); Chuckawalla Peak, Riverside Co., 2 May 1905, *Hall 5979* (S); Palm Springs, Feb. 1926, *Hart* (CA); near Oil City, Kern Co., 22 April 1905, *Heller 7743* (G, M, S); North Island, San Diego Co., July 1902, *Herre* (P); gravelly soil, San Felipe Wash, half way between Borego Valley and Yaqui Well, western Colorado Desert, San Diego Co., 26 Nov. 1927, *Howell 3247* (CA); sandy soil, east end of Morongo Valley, south Mojave Desert, alt. 90 m., San Bernardino Co., 11 March 1928, *Howell 3409* (CA, S); Barstow, Mohave Desert, alt. 700 m., June 1912, *Jepson 4784* (S); San Diego, 16 March 1882, *Jones 3076* (CA, M, P, S); Palm Spring, alt. 61 m., 10 May 1903, *Jones* (CA, P, S); Bakersfield, alt. 305 m., 23 May 1903, *Jones* (P); Funereal Mts., Death Valley, 10 April 1907, *Jones* (P); Barstow, 18 March 1924, *Jones* (S); Old Woman Mts., eastern Mohave Desert, 13 May 1926, *Jones* (P, S); Big Panoche Pass, 12 miles east of Llanada, San Benito Co., 27 Sept. 1932, *Keck 1833* (CA, S); Cuyana Valley, on Ozena road, 3 miles from Santa Maria-Maricopa road, Santa Barbara Co., 6 May 1933, *Keck 2248* (CA, P, S); south of Bakersfield, March 1925, *McCalla* (CA); Morongo Valley, Riverside Co., 20 March 1936, *MacFadden 14475* (CA); Jacumba-Laguna Mts., alt. 760 m., 9 July 1916, *McGregor 138* (S); near Jacumba, 27 June 1925, *McMinn 1431* (S); Jacumba Hot Springs, near Monument No. 233, 29 May 1894, *Mearns 3332* (G, M, S, US); Mountain Springs, 10 May 1894, *Mearns 3024* (S); vicinity of Monument 258 P, International Boundary, 15 July 1894, *Mearns 3923* (S); Jacumba Hot Springs, 24 May 1894, *Mearns & Schoenfeldt 3260* (CA, S, US); dry sandy wash 10 miles west of 29 Palms, alt. 1060 m., 1 May 1921, *Munz 4548* (P); dry slope near Cottonwood Creek and below Barrett Dam, San Diego Co., 10 May 1924, *Munz 8026* (G, P); sandy wash, Sheephole Mts., southern Mohave Desert, alt. 1060 m., 8 April 1935, *Munz 13805* (P, S); sand wash, Mason Valley, eastern San Diego Co., 30 April 1932, *Munz & Hitchcock 12072, 12073* (M, P); dry rocky mesa between Whitewater and Mission Creek, Colorado Desert, 7 May 1922, *Munz &*

Johnston 5286 (P); mountains near Campo, San Diego Co., April 1889, *Orcutt* (M); southwestern part of the Colorado Desert, San Diego Co., April 1889, *Orcutt* (M); Jamul Valley, southern part of San Diego Co., 25 June 1875, *Palmer 364* (Buf, G TYPE, M); San Diego, southern part of San Diego Co., June 1875, *Palmer 365* (Buf, G, M); Whitewater, March 1881, *Parish & Parish 653, 1153* (M, S); Kern River, 1881, *Parry* (M); sandspit opposite San Diego, 17 March 1882, *Parry* (M); San Diego, April 1882, *Parry* (M); Colorado Desert, 6 Dec. 1881, *Pringle* (M); in sand between desert rocks, Mountain Springs, alt. 790 m., San Diego Co., 2 May 1918, *Spencer 807* (CA, G, P); Coronado Beach, San Diego Co., July 1895, *Stokes* (S); Panoche, April 1930, *Van Dyke* (CA); 29 Palms Canyon, Riverside Co., 18 March 1937, *Winblad* (CA); 4½ miles east of Campo, alt. 760 m., on the road to Jacumba, San Diego Co., 27 May 1931, *Wolf 2146* (P, S); Colorado Desert, March 1881, *Wright 188* (G).

BAJA CALIFORNIA: adobe hillside, Refugio Ranch, alt. 620 m., 28 March 1925, *Ballou* (P); near Enseñada, 9 Sept. 1923, *Eastwood 12358* (CA); dunes and sandy slopes, San Quintin, 5 April 1936, *Epling & Stewart* (S); in wash, Santo Tomas Valley at Santo Tomas, 1 March 1934, *Ferris & Bacigalupi 8502* (P, S, US); Jacumba, 2800 ft., 9 July 1922, *Fisher 37* (US); dry hills southwest of Valle Redondo, 30 May 1932, *Fosberg 8381* (M, P, S); San Jose, Tecate, 27 Nov. 1922, *Gallegos 1355* (US); La Huerta at west base of Hanson-Laguna Mts., alt. 850 m., 2 June 1905, *Goldman 1127* (US); Trinidad Valley, northwest base of San Pedro Martir Mts., alt. 820 m., 4 July 1905, *Goldman 1196* (US); San Matias Pass near Diablito Spring, Valle de Trinidad, 26 March 1936, *Harbison 14851* (S); near Santo Tomas, March 1935, *Harvey 535* (US); hills and bluffs near ocean, Enseñada, 7 April 1921, *Johnston 3020* (CA, G, US); Colnet, 15 April 1925, *Jones* (P); San Quintin Bay, 7 June 1925, *Mason 2058, 2059* (CA, US); San Ysidro Ranch, 2 July 1894, *Mearns 3864* (US); about rocks, 50 miles southeast of Tecate, 13 April 1925, *Munz 9567* (P); dry rocky slope 50 miles southeast of Tecate, alt. 1375 m., 13 May 1925, *Munz 9570* (P); Enseñada, 28 Feb. 1906, *Nelson & Goldman 7548* (US); San Selmo, Encinada district, June 1928, *Nutter-Cox* (CA); San Rafael Valley, 18 March 1885, *Orcutt 1271* (C, M); hillside ten miles south of Enseñada, 24 March 1937, *Purer 7127* (M); mountain pass 15 miles south of El Marmol, 2 Feb. 1929, *Reed 6215* (P); wash 2 miles north of Socorro, 4 Feb. 1929, *Reed 6320* (P); San Ysidro, 28 June 1894, *Schoenfeldt 3805* (US); south slope, 8 miles from Rosario on road to El Marmol, 4 March 1930, *Wiggins 4340* (S); in wash, 10 miles from El Marmol, 6 March 1930, *Wiggins 4379* (S); coastal slope 3–4 kilometers north of Enseñada, 12 Sept. 1929, *Wiggins & Gillespie 4016* (CA, G, M, P, S, US); canyon and adjacent slopes, 15–20 miles east of Enseñada on road to Ojos Negros, 14 Sept. 1929, *Wiggins & Gillespie 4062* (CA, S); juniper-covered slopes in vicinity of Ojos Negros, 15 Sept. 1929, *Wiggins & Gillespie 4085* (CA, G, M, P, S, US).

E. californica may be readily distinguished from the other species with ternate leaf arrangement by the browned and thickened leaves of the older stems.

7. **Ephedra aspera** Engelm. ex Wats. in Proc. Am. Acad. **18**: 157. 1883.

E. peninsularis Johnston in Univ. Calif. Pub. Bot. **7**: 437. 1922.

E. Reedii Cory in Rhodora **40**: 216. 1938.

Erect dioecious shrub, 0.25–1.25 m. high; branches rigid, firm, terete, up to 3 mm. thick, opposite or whorled at the nodes, angle of divergence about 35 degrees; internodes 1–5.5 cm. long; young stems pale to dark green, strongly asperous to smooth and glaucous, with numerous small longitudinal furrows, becoming yellow; bark of older stems cinereous, cracked and fissured; terminal buds obtuse-conical; leaves opposite, very rarely ternately whorled, 1–2.5 mm. long, obtusely tipped from a dorso-median thickening, connate for one-half to seven eighths their length; sheath splitting but the parts subpersistent; staminate spikes paired, rarely solitary or whorled, at the nodes of the young branches, obovate, 4–7 mm. long, sessile, or rarely short-pedunculate, bracts opposite, in 6–10 whorls, obovate, 3 mm. long, 2 mm. broad, membranaceous, yellow to red-brown, the lower whorl empty; perianth slightly exceeding the subtending bract; staminal column 4–5 mm. long, one-third exserted, with 4–6 sessile or very short-stipitate anthers; ovulate spikes paired, occasionally solitary, or whorled at the nodes of the young branches, ovate, 6–10 mm. long, sessile or short- and scaly-pedunculate, bracts opposite, in 5–7 whorls, orbicular, 2–5 mm. long, 2–5 mm. broad, thickened, red-brown, margins membranaceous; seed solitary, in cross-section circular to slightly trigonal, with a minute indentation at the tip between the angles, smooth to slightly roughened, light brown to chestnut, 5–8 mm. long, 2.5–4 mm. broad, exceeding by one-third the bracts; tubillus slightly exserted, almost straight, the limb contorted.

Distribution: southwestern United States and northern Mexico.

Specimens examined:

Texas: rocky hills and dry ravines, Frontera, *Bigelow 2* (G); Fort Bliss, 16 June 1917, *Clemens* (CA, P); Marathon, Brewster Co., 20 April 1928, *Cory 920* (G); Brewster Co., 21 April 1928, *Cory 922* (G); Reagan Canyon, Brewster Co., 22 April 1928, *Cory 924* (G); 55.4 miles south of Alpine, Brewster Co., 13 April 1936, *Cory 18547* (G) type of *E. Reedii;* same locality *18548* (TAM); 9 miles north of Sander-

son, Terrell Co., 15 April 1936, *Cory 18736* (G); along railroad, 8 miles west of Sanderson, Terrell Co., 26 May 1938, *Cutler 1846* (M); on talus and summit, Persimmon Gap, Santiago Mts., Brewster Co., 27 May 1938, *Cutler 1851* (M); gravel plain, 8 miles north of Glenn Spring, Brewster Co., 27 May 1938, *Cutler 1863–1868* (M); gravel plain and talus, Fresno Canyon, 25 miles north of Lajitas, Presidio Co., 29 May 1938, *Cutler 1903–1905* (M); gravel plain, 16 miles north of Presidio, Presidio Co., 31 May 1938, *Cutler 1926* (M); slopes and summit, Beach Mts., 8 miles north of Van Horn, Culberson Co., 2–3 June 1938, *Cutler 1958, 1963, 1964, 1966, 1969* (M); canyons near Devil's River, Valverde Co., 13 Sept. 1900, *Eggert* (M); stony hills near Van Horn, 12 May 1901, *Eggert* (M); flats near Van Horn, 12 May 1901, *Eggert* (M); rocky hills near Van Horn, 9 July 1900, *Eggert* (M); alt. 1100 m., southern Brewster Co., 13 July 1927, *Fisher* (P); El Paso, 18 April 1884, *Jones 3726* (CA, F, NMAM, P, S); Indian Hot Springs, 30 April 1930, *Jones 25963* (CA, M, P, S); west of Fort Stockton, 18 April 1931, *Jones 28372* (P); top of Organ Mts., Aug. 1900, *Lemmon 287* (C); Chisos Mts., Aug. 1935, *Marsh 64* (P); Terlingua, Brewster Co., 16 July 1937, *Marsh 103* (F); gravelly mesa north of Chisos Mts., alt. 1065 m., 27 June 1931, *Moore & Steyermark 3258* (CA, G, M, S); Chisos Mts., 28 June 1931, *Mueller 7951* (M); Sierra Blanca, 5 July 1895, *Mulford 272* (M); dry rocky ground near mouth of Pecos River, Valverde Co., 24 April 1928, *Palmer 33475* (M); dry rocky and gravelly ground, plains and foothills of Chisos Mts., 24 May 1928, *Palmer 34145* (M); western Texas, 22 May 1888, *Pringle* (R); vicinity of El Paso, 29 March 1908, *Rose 11634* (G); west base of Lone Mt., Chisos Mts., 21 Feb. 1937, *Sperry 558, 559* (US); El Paso, 188–, *Vasey* (F, I, M); Mt. Franklin, 20 March 1932, *Whitehouse 8340* (CA, F); western Texas, to Frontera, coll. of 1851, *Wright 1883* (M); rocky hills near Frontera, 4 May 1852, *Wright 273?* (G); foothills of Chenate Mts., 9 Sept. 1914, *Young 53* (M).

New Mexico: Pino Blanca, south end of Organ Mts., alt. 1500 m., Dona Ana Co., 11 Sept. 1930, *Fosberg 83960* (P); foot of cliffs near mouth of North Fork, near Three Forks of Rocky Arroyo, Guadalupe Mts., 28 April 1932, *Wilkens 1653* (S); Bishop's Gap, Organ Mts., 4 April 1903, *Wooton* (NMAM).

Arizona: Roosevelt Dam, 17 May 1919, *Eastwood 8676* (CA); Coyote Pass on road from Kingman to Oatman, 16 May 1931, *Eastwood 18425* (CA); Yucca, 14 May 1884, *Jones* (P); near Phoenix, 1880, *Lemmon 252* (G, M); Tucson, 1880, *Lemmon* (M); Coyote Pass, between Kingman and Oatman, 16 May 1931, *McKelvey 2253* (P); Sierra Tucson, 27 May 1884, *Pringle 39* (G); Tempe, 1 April 1894, *Toumey* (S).

California: between Tehachapi and Mojave, 28 June 1908, *Abrams & McGregor 499* (G); eastern base of Coast Range, edge of Colorado Desert, 7 May 1894, *Mearns 2956* (G, M, S); Mountain Springs, San Diego Co., 12 May 1894, *Mearns & Schoenfeldt 3079* (S, US); vicinity of Bonanza King Mine, east slope of Providence Mts., Mojave Desert, alt. 900 m., 21–24 May 1920, *Munz, Johnston & Harwood 4029* (P); Vallecito, June 1882, *Parish & Parish* (M).

Mexico:

tamaulipas: mountains near Miquihuana, alt. 2100–2700 m., 10 June 1898, *Nelson 4472* (F, G, US).

san luis potosi: Sierra de Guascama, Minas de San Rafael, May 1911, *Purpus 5334* (G, M, US).

COAHUILA: dry valley west of Castanuela, 11 April 1847, *Gregg 414* (M); west of Castanuela, 1848–49, *Gregg 53* in part (G); Sierra Madre, 40 miles south of Saltillo, July 1880, *Palmer 1288* (G, M TYPE, US); Saltillo and vicinity, 15–30 April 1898, *Palmer 69* (G, M, UC, US); Sierra de Parras, March 1905, *Purpus 1102* (F, G, M, P); rocky slopes of El Puerto de San Lazaro, San Lazaro, Municipio de Castaños, 17 June 1936, *Wynd & Mueller 143* (M, US).

ZACATECAS: high ridges, Cedros, June 1908, *Kirkwood 24* (F, G); hills, Cedros, June 1908, *Kirkwood & Lloyd 86* (F, M, US).

CHIHUAHUA: Sta. Eulalia Mts., 4 June 1885, *Pringle 38* (G, M, US); Sta. Eulalia plains, 1885, *Wilkinson 118* (F, US).

BAJA CALIFORNIA: Cedros Island, March–June 1897, *Anthony 281* (F, M, S, UC, US); Magdalena Island, 12 Jan. 1889, *Brandegee* (UC), type of *E. peninsularis;* Calamalli, 25 April 1889, *Brandegee* (UC); Cedros Island, 1 April 1897, *Brandegee* (UC); near Canyon Diablo, 20 miles east, 1 May 1933, *Harvey 588* (US); among loose rocks on an old lava flow, Coronados Island, Gulf of California, 18 May 1921, *Johnston 3757* (CA, UC, US); north of Turtle Bay, 2 June 1925, *Mason 1976, 1977* (CA, F, US); Cedros Island, 3 June 1925, *Mason 2021* (US); north end of Cedros Island, 6 June 1925, *Mason 2021a* (CA, US); Cedros Island, 18–20 March 1889, *Palmer 695* (US); Bay of San Bartolome, 27 April 1889, *Pond* (US); rocky soil near Calmalli, alt. 450 m., Jan.–March 1898, *Purpus 6* (F, S, UC, US); Cape region, near Las Animas, Jan.–March 1901, *Purpus 269* (UC); Cedros Island, 11 March 1911, *Rose 16140* (US); San Bartolome Bay, 14 March 1911, *Rose 16236* (US); 20 miles east of Rosario, 8 Feb. 1935, *Shreve 6842* (F).

Although the type description states: "the seed in pairs," all the specimens on the type sheet have the seeds solitary within the strobilus. The strobili, however, are paired at the nodes, and a note on *Palmer 69,* "the female plant has a few very dry seeds attached," indicates that the term "seed" was used for the entire strobilus.

8. **Ephedra fasciculata** A. Nelson in Am. Jour. Bot. **21**: 573. 1935.

Dioecious shrub, often prostrate, 0.25–1 m. high; branches flexuous, solid, terete, up to 3.5 mm. thick, opposite or whorled at the nodes, angle of divergence from the main stem about 35 degrees; internodes 1–5 cm. long; young stems pale green, very slightly asperous to smooth and glaucous, with small longitudinal furrows, becoming yellowed; bark cinereous, cracked and fissured; terminal buds 1–3 mm. long, obtusely conical; leaves opposite, 1–3 mm. long, obtusely tipped from a barely perceptible dorso-median thickening, connate for two-thirds to three-fourths their length at first, later splitting; sheath

hyaline, white, subpersistent; staminate spikes paired or several at the nodes of the young branches, narrowly elliptic, 4–8 mm. long, sessile, bracts opposite, slightly connate, in 4–8 whorls, obovate, 2–3 mm. long, 2 mm. broad, membranaceous, light yellow, the lower whorls empty; perianth exceeding the subtending bract; staminal column 3–9 mm. long, one-fourth to three-fourths exserted, with 6–10 sessile or very short-stipitate anthers; ovulate spikes solitary or several at the nodes of the young branches, elliptic, 6–13 mm. long, sessile or short-pedunculate, bracts opposite, in 4–7 whorls, slightly connate at the base, elliptic, 3–7 mm. long, 2–4 mm. broad, margins hyaline, the back slightly thickened and light brown to green; seed usually solitary, in cross-section almost circular, with numerous longitudinal furrows, light brown, 8–13 mm. long, 3–5 mm. in diameter, one-third to one-half exceeding the bracts; tubillus straight, barely exserted, the ligulate limb bent and slightly contorted.

Distribution: Arizona and southern California.

Specimens examined:

Arizona: Pinal Mts., 18 May 1929, *Eastwood 17314* (CA); Phoenix, alt. 300 m., 6 May 1903, *Jones* (P); Sierra Estrella, 13 April 1931, *Kearney & Peebles 7748, 7759* (P); Tule Tank, Yuma Co., 23 March 1935, *Kearney & Peebles 10897* (P); dry slope, trail from Colorado River to Rampart Cave, Lower Grand Canyon, Mohave Co., 16 June 1937, *Munz 14983* (P); dry sand banks, Phoenix, 2 May 1925, *Nelson 10286* (R type, M, S); rocky slopes, vicinity of Canyon Lake, Apache Trail, 1 May 1935, *Nelson & Nelson 1716* (M).

California: Kelso, Mohave Desert, alt. 900 m., 2 May 1906, *Jones* (P); canyon near Agua Caliente, April 1882, *Parish & Parish 1238* (G, I, M, S).

9. **Ephedra Clokeyi** Cutler,[27] n. sp.

Erect dioecious shrub, 0.5–1 m. high; branches rigid, solid, terete, up to 3.5 mm. thick, opposite or whorled at the nodes, angle of divergence with the main stem about 40 degrees; inter-

[27] **Ephedra Clokeyi** Cutler, sp. nov.; frutex erectus, dioiceus, 0.5–1 m. altus; ramulis rigidis, solidis, teretibus, usque ad 3.5 mm. in diametro, ad nodos oppositis vel verticillatis, angulo declinationis circiter 40°; internodiis 2–5 cm. longis; caulibus juventate pallide viridibus, parce scabris vel laevibus et glaucis, tenuissime striatis, deinde lutescentibus; rhytidoma cinerea, rimosa, sulcata; gemmis terminalibus 2–3 mm. longis, obtuso-conicis; foliis oppositis, 1–3 mm. longis, ad

nodes 2–5 cm. long; young stems pale green, slightly asperous to smooth and glaucous, with numerous small longitudinal furrows, becoming yellowed; bark cinereous, cracked and fissured; terminal buds 2–3 mm. long, obtuse-conical; leaves opposite, 1–3 mm. long, obtusely tipped from a dorso-median thickening, connate for one-half to seven eighths their length at first, later split; sheath membranaceous, deciduous; staminate spikes paired or numerous at the nodes of the young branches, obovate, 4–7 mm. long, sessile or very short-pedunculate, bracts opposite, slightly connate, in 5–8 whorls, obovate, 2–3 mm. long, 2 mm. broad, membranaceous, light yellow to light brown, the lower whorls empty; perianth exceeding the subtending bract; staminal column 3–6 mm. long, one-fourth to two-thirds exserted, with 6–9 sessile or very short-stipitate anthers; ovulate spikes paired or numerous at the nodes of the young branches, obovate, 6–10 mm. long, sessile or short-pedunculate, bracts opposite, in 5–8 whorls, slightly connate at the base, broadly elliptic, 3–5 mm. long, 2–4 mm. broad, margins hyaline, the back slightly thickened, light brown to green; seed usually solitary, in cross-section almost circular, with numerous longitudinal furrows, light brown, 5–8 mm. long, 2.8–4 mm. broad; tubillus straight, slightly exserted, the ligulate limb bent and contorted.

Distribution: southern Utah, Arizona, Nevada and southern California.

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apicem obtusis ex dorso-medio crassificatione, primo ad ½–⅞ longitudinis connatis, deinde diffisis; vagina membranacea, decidua; spicis stamineis paribus vel multis ad nodos ramulorum novorum, obovatis, 4–7 mm. longis, sessilibus vel brevi-pedunculatis, bracteis oppositis, parce connatis, in 5–8 verticillis, obovatis, 2–3 mm. longis, 2 mm. latis, membranaceis, pallide luteis vel pallide fulvis, bractearum verticillis inferioribus vacuis; perianthis bracteas subtendentes superantibus; columna staminale 3–6 mm. longa, ¼–⅔ exserta, antheris 6–9 sessilibus vel brevissime stipitatis; spicis femineis paribus vel multis ad nodos ramulorum novorum, obovatis, 6–10 mm. longis, sessilibus vel brevi-pedunculatis, bracteis oppositis, in verticillis 5–8, ad basem parce connatis, late ellipticis, 3–5 mm. longis, 2–4 mm. latis, marginibus hyalinis, dorso parce crassatis, pallide fulvis vel viridibus; seminibus plerumque solitariis, in sectione transverse suborbicularibus, sulcis multis longitudinalibus, pallide fulvis, 5–8 mm. longis, 2.8–4 mm. latis; tubillo recto, leviter exserto, limbo ligulato curvato et contorto.

SPECIMENS EXAMINED:

ARIZONA: canyon above Antler, Mohave Co., 8 April 1928, *Braem* (S); Hermit Trail, Grand Canyon, 9 April 1917, *Eastwood 5965* (CA); Hermit Creek, Grand Canyon, 10 April 1917, *Eastwood 6004a, 6017* (CA); Grand Canyon of the Colorado, 11 April 1917, *Eastwood 6032, 6040* (CA); Hermit Trail, 12 April 1917, *Eastwood 6057* (CA); Bright Angel Trail, Grand Canyon, 14 April 1917, *Eastwood 6100* (CA); Roosevelt Dam, 19 April 1917, *Eastwood 6212* (CA); Hieroglyphic Canyon, Salt River Mts., alt. 500 m., Maricopa Co., 24 March 1932, *Gillespie 5529* (P, S, UC); near Oatman, 23 March 1931, *Harrison & Kearney 7586* (F); Chimehuevis, alt. 1400 m., 21 April 1903, *Jones* (P); Hammock, 17 March 1932, *Jones 29008* (M, P); among the lava rocks, Duncan, 22 March 1930, *Nelson 11280a* (G, S).

UTAH: St. George, 2 April 1880, *Jones* (M, S); southern Utah, 1874, *Parry 249* (F, G, I, M); valley of the Virgen near St. George, 1874, *Parry 249* (G); southern Utah, 1874, *Parry 251* in part (G, M).

NEVADA: gravel, Mica Spring, alt. 1200 m., 14 April 1894, *Jones 5062* (G, M, P, US); Logan, 5 May 1909, *Kennedy 1841* (I, G, S); rocky slopes of small gully, Frenchman Mt., northeast of Las Vegas, 30 May 1933, *Munz 12955* (P).

CALIFORNIA: rocky slope and wash, desert, Cottonwood Springs, Riverside Co., 17 April 1935, *Clokey 6510, 6511, 6512* (Clo, M); among rocks, hillside and wash, desert, Cottonwood Springs, Riverside Co., 17 April 1935, *Clokey 6513* (Clo, M TYPE); rocky slopes and wash in desert, Cottonwood Springs, 17 April 1935, *Clokey 6514* (Clo, M); gravelly hills and ravines, Fort Mojave, 25 Feb. 1861, *Cooper* (M); Box Canyon, San Diego Co., April 1932, *Epling & Robison* (CA, M, S); at bridge in Sentenac Canyon, San Diego Co., 7 March 1935, *Gander 138.12* (SD); Borego Palm Canyon, San Diego Co., 14 April 1936, *Gander 1275* (SD); desert along mountains, alt. 300–770 m., Palm Canyon, Riverside Co., 4 April 1917, *Johnston* (P, S); Imperial Valley, 28 Feb. 1924, *Jones* (P); walls of Box Canyon, western Colorado Desert, eastern San Diego Co., 2 April 1932, *Munz & Hitchcock 12047* (F, M, P); dry rocky slopes, vicinity of Corn Springs, Chuckwalla Mts., Colorado Desert, alt. 460 m., 9–12 April 1922, *Munz & Keck 4789* (P); Mountain Springs, 6 April 1914, *Parish 9070* (S); desert sand, Mountain Springs, San Diego Co., 26 March 1917, *Spencer 206* (G, P); on highway 80, Mountain Springs grade, about 1 mile east of Mountain Springs service station, Imperial Co., western edge of Imperial Valley (Colorado Desert), alt. 250–270 m., 1 May 1938, *Whitaker* (M).

This species has been included under *E. nevadensis* Wats. by most botanists but differs from it in having a solitary seed within the strobilus in contrast to the paired seeds of *E. nevadensis*.

10. **Ephedra nevadensis** Watson in Proc. Am. Acad. **14**: 298. 1879.

E. antisyphilitica Wats. in U. S. Geol. Surv. Fortieth Parallel [Bot. King's Exp.] **5**: 329, *pl. 39.* 1871, *not* C. A. Mey.

E. antisyphilitica var. *pedunculata* Watson, *loc. cit.*

E. nevadensis Wats. subvar. *paucibracteata* Stapf in Denkschr. K. Akad. Wiss. Wien **56**[2]: 83. 1889.

Erect dioecious shrub, 0.25–1.25 m. high; branches rigid to flexuous, solid, terete, up to 4 mm. thick, opposite or whorled at the nodes, angle of branch-divergence about 45 degrees; internodes 1.5–6 cm. long; young stems pale green, glaucous, almost smooth, with small longitudinal furrows, becoming yellow, then gray; bark cinereous, fissured; leaves binate, rarely ternate, 2–4 mm., rarely to 8 mm. long, obtusely tipped from a dorso-median thickening, connate for one-half to two-thirds their length, later splitting and falling off; staminate spikes solitary to several at the nodes of the young branches, elliptic, 4–8 mm. long, sessile to short-pedunculate, bracts opposite, in 5–9 whorls, obovate, 3–4 mm. long, 2–3 mm. broad, membranaceous, yellow to light brown, the lower whorl empty; perianth slightly exceeding the subtending bracts; staminal column 3–5 mm. long, one-quarter to one-half exserted, with 6–9 sessile to short-stipitate anthers; ovulate spikes solitary to several at the nodes of the young branches, suborbicular, 5–11 mm. long, borne on an almost naked 1–50-mm. long peduncle, bracts binate, in 3–5 whorls, suborbicular, connate at the base, 4–8 mm. long, 3–6 mm. broad, herbaceous, light brown to yellow-green, occasionally tinged with pink; seeds paired, rarely solitary, brown, smooth, 6–9 mm. long, 2–4 mm. broad, equaling or exceeding the bracts; tubillus moderately exserted, slightly recurved, barely contorted.

Distribution: Utah, western Arizona, Nevada, Oregon and California.

SPECIMENS EXAMINED:

ARIZONA: Kingman, 14 April 1931, *Eastwood 18007* (CA); Hackberry, 24 May 1884, *Jones* (P); Camp Lowell, 1880, *Lemmon 251* (G).

UTAH: southwest of St. George, alt. 900 m., Washington Co., 3 June 1929, *Cottam 4083* (BYU, P); sandy soil, Santa Clara Bench, alt. 900 m., Washington Co., 24 April 1930, *Cottam 4701* (BYU); dry clay loam, roadside, 6 miles west of Hinckley, alt. 1520 m., Millard Co., 9 May 1935, *Harrison 6305, 6306* (BYU); Santa Clara, 8 April 1880, *Jones* (M); St. George, 2 April 1880, *Jones* (M, S); Frisco, 225 miles southwest of Salt Lake, 22 April 1880, *Jones* (M); Milford, 17 June 1880, *Jones* (P); Milford, 19 June 1880, *Jones* (P); Milford, 22 June 1880, *Jones 1802*

in part (CA); gravel, Marysvale, alt. 1820 m., 4 June 1894, *Jones 5388ag* (CA, P); Dutch Mt., alt. 1620 m., Tooele Co., 15 June 1900, *Jones* (P); Vermilion, 4 June 1901, *Jones* (P); Price Valley, alt. 1520 m., 3 July 1903, *Jones* (P); Leamington, alt. 1520 m., 8 May 1911, *Jones* (CA, S); near Salt Lake, *Macbride* (UI); rocky slopes above public camp, Zion National Park, 2 April 1934, *Maguire, Maguire & Maguire 4723* (M); bluffs near Price, alt. 1800 m., 11 June 1900, *Stokes* (S); slopes and mesas west of St. George, 6 May 1919, *Tidestrom 9303* (M, G, US).

NEVADA: gravelly wash, Kyle Canyon, Charleston Mts., 1350 m., Clark Co., 29 April 1938, *Clokey 7465* (Clo, M); near Pyramid Lake, 24 June 1927, *Eastwood 14734, 14736* (CA, P); sandy deserts near Walker River, 7 June 1859, *Engelmann* (M TYPE of *E. antisyphilitica* var. *pedunculata*, G); Columbus, alt. 1520 m., 20 May 1897, *Jones* (P); Good Springs, 1 May 1905, *Jones* (CA); Big Pine, 3 June 1924, *Jones* (P); Pyramid Lake, Washoe Co., 19 May 1905, *Kennedy 999* (M); Pyramid Lake, alt. 1310 m., 1 June 1913, *Kennedy 1988* (I, M, S); west shore of Pyramid Lake, May 1879, *Lemmon* (G, M); shad-scale desert, 17 miles north of Baker, White Pine Co., 16 June 1933, *Maguire & Becraft 2479* (G, M, P); Atlatl Park, Valley of Fire, Clark Co., 6 April 1934, *Maguire, Maguire & Maguire 4717* (M); in desert pavement, 14 miles north of Glendale, Lincoln Co., 6 April 1934, *Maguire, Maguire & Maguire 4719* (M); Corey Canyon, Wassuk Mts., alt. 1850 m., near Hawthorne, 27 June 1919, *Tidestrom 10099* (M, US); Smoky Valley, alt. 1675 m., July 1868, *Watson 1108* in part (G TYPE).

OREGON: very dry slopes of lower Pueblo Mts., above Catlow's ranch, Harney Co., 4 July 1927, *Henderson 8670* (CA).

CALIFORNIA: desert slopes, Jacumba, San Diego Co., 31 May 1903, *Abrams 3676* (G, M, P); Great Falls Canyon, Argus Mts., Mohave Desert, 18 April 1930, *Bailey & Robison* (CA, M); sandy soil, Walker Pass, Piute Mts., alt. 1200 m., Kern Co., 24 April 1932, *Benson 3446* (S); about 60 miles north of Los Angeles, June 1890, *Coquillett* (M, US); Mojave, Kern Co., 13 May 1913, *Eastwood 3220* (CA); between Jacumba and Mountain Springs, San Diego Co., 24 April 1920, *Eastwood 9522* (CA); between Victorville and Lucerne Valley, San Bernardino Co., 29 April 1932, *Eastwood 18716* (CA); on road to Barstow from Las Vegas, San Bernardino Co., 30 April 1932, *Eastwood 18766, 18791* (CA); Acton, Los Angeles Co., June 1902, *Elmer 3599* (M); Palmdale, 24 April 1926, *Epling* (M); in vacant lot, Lancaster, Los Angeles Co., 12 June 1918, *Ferris 909* (S); low desert hills, on shore of Owen's Lake near Gowan, Inyo Co., 11 July 1918, *Ferris 1347* (S); occasional on rocky slopes, eastern base of Hackberry Mt., near Goffs-Lanfair road, alt. 1100 m., San Bernardino Co., 24 April 1928, *Ferris 7283* (S); yucca-juniper forest, 23 miles west of Lancaster in Antelope Valley, Kern Co., 3 May 1929, *Ferris 7702* (P, S); in yucca grove on Tehachapi road, 6 miles from Mojave, 17–24 March 1924, *Ferris, Scott & Bacigalupi 3874* (S); hills near Victorville, alt. 1050 m., San Bernardino Co., May 1905, *Hall 6212* (S); between Lancaster and Victorville, 27 April 1930, *Hart* (CA); Randsburg, Kern Co., 14 April 1905, *Heller 7703* (M); sandy soil, open desert, Mojave Desert, alt. 900 m., 9 miles southeast of Victorville, San Bernardino Co., 11 June 1927, *Howell 2498* (CA); sandy soil, half way between Victorville and Hesperia, Mojave Desert, alt. 900 m., San Bernardino Co., 12 June 1927, *Howell 2529* (CA); Mohave Desert, near Barstow, alt. 800 m., 8 June 1912, *Jepson 4831* (S); hillside, Victorville, 15 May 1920, *Johnston* (P); in sunny, hot, sandy stretches, Deadman Point, Mohave Desert, alt. 900 m., 10 May 1920, *Johnston* (P);

Bishop, Owen's Valley, alt. 1220 m., 15 May 1897, *Jones* (M, P); Victor, alt. 800 m., 17 May 1903, *Jones* (P); west slope of Walker Pass, alt. 1370 m., Kern Co., 5 May 1932, *Munz 12468* (M, P); Mohave River, southeast California, 1 June 1876, *Palmer 524* (G, M, co-types of *E. nevadensis* subvar. *paucibracteata)*; Warren's Well, San Bernardino Mts., alt. 1060 m., 16 June 1894, *Parish 2974* (M); Hesperia, Mojave Desert, 30 May 1918, *Parish 11841* (M, P, S); mountains of the Mojave Desert, March 1882, *Parish & Parish 1368* (M); Cushenberry Springs, Mojave Desert, May 1882, *Parish & Parish 1369* (S); Mojave Desert, May 1882, *Parish & Parish 1369* (G, M); Mohave Desert, 31 May 1882, *Pringle* (M); sandy soil, Argus Mts., alt. 1200–1500 m., April–Sept. 1897, *Purpus 5032* (G, M); Hesperia, April 1892, *Trelease* (M).

The type collection of *E. nevadensis* consists of two species, staminate material of what is now considered *E. nevadensis*, and ovulate material of *E. viridis*. The description by Watson stressed the staminate material and mentioned it first and as Californian specimens of *E. viridis* were cited as being peculiar and perhaps distinct, this is interpreted as leaving the staminate material of Watson's collection as the type. Other material cited in the original description is that of Cooper from Fort Mohave, California *(E. Clokeyi)*; of Gregg from northern Mexico (no number is given but this is probably *E. aspera)*; and a form from New Mexico with no collector or locality given but probably referring to Wright's or Bigelow's collection of *E. aspera* and stated to differ in having very short peduncles and solitary fruits. The form described as *E. Clokeyi* has been included under *E. nevadensis* by most contemporary botanists but is distinct, having only one seed surrounded by membranaceous bracts as opposed to the paired seeds surrounded by herbaceous bracts in *E. nevadensis*.

This species varies greatly, the southern forms mostly smaller and dark-stemmed; the northern forms with large and almost herbaceous, light-colored stems. The very young shoots are frequently marked by a ternate arrangement of some whorls of leaves.

10a. Ephedra nevadensis forma **rosea** Cutler,[28] n. f.

Differs from the species in having roseate bracts, seeds less than 5.5 mm. long.

[28] **Ephedra nevadensis** forma **rosea** Cutler, f. nov., a specie differt bracteis roseis, seminibus usque ad 5.5 mm. longis.

Distribution: western Nevada and adjacent California.

SPECIMENS EXAMINED:

NEVADA: near Pyramid Lake, 24 June 1927, *Eastwood 14744* (CA TYPE).

CALIFORNIA: Willow Springs, Kern Co., 1 July 1905, *Grinnell 436* (US).

11. **Ephedra viridis** Coville in Contrib. U. S. Nat. Herb. **4**: 220. 1893.

E. nevadensis var. *viridis* (Coville) Jones in Proc. Calif. Acad. II, **5**: 726. 1895.

E. nevadensis subvar. *pluribracteata* Stapf in Denkschr. K. Akad. Wiss. Wien **56**^{2}: 83. 1889.

Erect dioecious shrub, 0.5–1 m. high; branches rigid, firm, terete, up to 3 mm. thick, opposite or numerous at the nodes, angle of divergence about 33 degrees; internodes 1–4.5 cm. long; young stems bright-green to yellow-green, later yellowed; bark of older stems cinereous, cracked and fissured; terminal buds 1–2 mm. long, obtuse-conical; leaves opposite, 1.5–4 mm. long, obtusely to setaceously tipped from a dorsomedian thickening, connate for one-third to three-fourths their length, sheath membranaceous-margined, soon falling to leave the thickened and persistent brown base; staminate spikes paired or numerous at the nodes of the young branches, obovate, 5–7 mm. long, sessile, bracts opposite, barely connate at the base, in 6–10 whorls, ovate, 2–4 mm. long, 2–3 mm. broad, membranaceous, light yellow, slightly reddened, the lower whorl empty; perianth slightly exceeding the subtending bract; staminal column 2–4 mm. long, one-fourth to one-half exserted, with 5–8 sessile or almost sessile anthers; ovulate spikes opposite or several at the nodes of the young branches, obovate, 6–10 mm. long, sessile or on short, scaly peduncles, bracts opposite, in 4–8 whorls, ovate, 4–7 mm. long, 2–4 mm. broad; seeds paired, light brown to brown, trigonal, smooth, 5–8 mm. long, usually exceeding the bracts by one-fourth; tubillus straight or slightly bent, exserted, the ligulate limb slightly contorted and meagerly recurved.

Distribution: western Colorado, Utah, western Arizona, Nevada and California.

SPECIMENS EXAMINED:

COLORADO: slopes, upper juniper area, Uncompahgre Plateau, west of Delta, 6 June 1909, *Tidestrom 2170* (US).

ARIZONA: below Beaver Dam divide, Mohave Co., 11 May 1938, *Barkley 3333* (M); edge of Walnut Creek, alt. 2000 m., 1 July 1909, *Burrall* (US); near rim of Grand Canyon, east of Point Hope, 3 April 1918, *Collins* (G); dry flats, Lee's Ferry, alt. 1050 m., Coconino Co., 6 July 1927, *Cottam 2610* (BYU); Bright Angel Trail, Grand Canyon, 26–28 Sept. 1913, *Eastwood 3599* (CA); Grand View Trail, Grand Canyon, 16 June 1916, *Eastwood 5715, 5759* (CA); Hermit Trail, Grand Canyon, 18 June 1916, *Eastwood 5872* (CA); Hermit Creek, 10 April 1917, *Eastwood 6026* (CA); trail to Monument Creek, 11 April 1917, *Eastwood 6033, 6042* (CA); Bright Angel Trail, Grand Canyon, 14 April 1917, *Eastwood 6109* (CA); north rim, Grand Canyon, 22 June 1933, *Eastwood & Howell 934* (CA); mesa between Fredonia and Ryan City, alt. 2000 m., Coconino Co., 8 July 1914, *Eggleston 10191* (P); Bright Angel Trail, Grand Canyon, alt. 1220 m., 31 May 1913, *Goldman 2075* (US); Bright Angel Trail, alt. 2080 m., 19 Aug. 1913, *Goldman 2210* (US); near the hotel, Grand Canyon, 25 April 1905, *Goulding* (S); Grand Canyon, 24 May 1903, *Grant 5644* (CA, M, P, S); canyon 2 miles below Pagumpa, alt. 1220 m., 21 April 1894, *Jones 5089r* (P); mesa below Buckskin Mts., alt. 2120 m., 21 Sept. 1894, *Jones 6063q* (P); Chloride, alt. 1370 m., 14 April 1903, *Jones* (P); Chimehuevis, alt. 980 m., 21 April 1903, *Jones* (P); Peach Springs, 14 June 1929, *Jones* (P); Valentine, Mohave Co., 17 April 1934, *Kearney & Peebles 11107* (US); Walnut Canyon, 19 May 1891, *MacDougall 100* (US); near Canyon Diablo, Coconino Co., 18 May 1931, *McKelvey 2285* (P); Bright Angel Trail, Grand Canyon, 6 May 1917, *Meiere* (CA); edge of Walnut Creek, Coconino National Forest and vicinity, 1 July 1929, *Pearson 225* (US); near Flagstaff, June 1900, *Purpus 7087* (US); Holbrook, 6 May 1899, *Zuck* (M, US).

UTAH: west ridge of Virgen River, Zion National Park, 9 May 1938, *Barkley 3115* (M); hillsides, Hunt's ranch, alt. 1800 m., Washington Co., 26 Aug. 1927, *Cottam 1189* (BYU); crevices of lava rock, Veyo, alt. 1750 m., Washington Co., 21 June 1928, *Cottam 3368* (BYU); mountain side, alt. 2000 m., Apex Mine, Washington Co., 4 June 1929, *Cottam 4115* (BYU, P); east of Escalante, alt. 1680 m., 18 June 1929, *Cottam 4380* (BYU); cliff, north of Antelope Springs, alt. 2250 m., Millard Co., 19 April 1930, *Cottam 4630* (BYU, M); foot of Lady Mt. Trail, Zion National Park, 19 June 1928, *Craig 1450* (P); among rocks in canyon, 8 miles west of Castle Dale, Emery Co., 25 June 1938, *Cutler 2373–2375* (M); canyon walls, 5 miles west of Elberta, Juab Co., 26 June 1938, *Cutler 2433–2435* (M); foothills 5 miles northeast of Ephraim, alt. 2000 m., San Pete Co., 20–26 May 1914, *Eggleston 10143* (US); Dry Fork Creek, just above Dry Fork town, alt. 2050 m., Uintah Co., 12 May 1935, *Graham 8813* (M); burned-over north slope of Calamity Ridge, south side of White River, 2 miles southeast of mouth of Wolf Creek, alt. 2000 m., 1 June 1935, *Graham 9073* (M, US); Red Wash, just northwest of mouth of Split Mt. Canyon, above Island Park, alt. 1600 m., Uintah Co., 10 June 1935, *Graham 9147* (M, US); on cliff, Cottonwood Creek Canyon, south of Minnie Maud Creek, alt. 1750 m., Carbon Co., 7 July 1935, *Graham 9521* (M, US); Diamond Valley, 22 April 1919, *Hall 527* (US); near Anderson's ranch, Washington Co., 28 July 1927, *Harris N27134* (M); Ephraim Plateau, 4 Aug. 1927, *Harris C27713* (M); rocky cliffs,

Desert Range Experiment Station, alt. 1750 m., Millard Co., 11 May 1935, *Harrison 6382S* (BYU, M); moist north slope, Tintic Mts., east of Eureka, alt. 2120 m., Juab Co., 22 May 1938, *Harrison 8328, 8329* (BYU); rocky sage-brush slope, Ashley Creek Canyon, about 10 miles northwest of Vernal, alt. 1630 m., 14 July 1933, *Hermann 4920* (M); St. George, 2 April 1880, *Jones* (M, P); Frisco, 22 June 1880, *Jones* (CA, M, P); Milford, alt. 1520 m., 22 June 1880, *Jones 1802* (NMAM, S, US); Dutch Mt., 12 June 1891, *Jones* (P); red sand, Belvue, alt. 1100 m., 30 March 1894, *Jones 5001k* (P); gravel, Diamond Valley, alt. 1370 m., 28 April 1894, *Jones 5124* (M, P, US); 10 miles below Kanarra, alt. 1370 m., 12 May 1894, *Jones 5213d* (US); red sand, Johnson, alt. 1600 m., 23 May 1894, *Jones 5289y* (P); red sand, Pahria Canyon, alt. 1600 m., 26 May 1894, *Jones 5297v* (P); gravel, Marvine Laccolite, alt. 1800 m., 23 July 1894, *Jones 5663bf* (P); Monroe, Sevier Co., alt. 1680 m., 24 May 1899, *Jones* (P); Miller Creek, alt. 1800 m., 8 June 1910, *Jones* (P); along Hurricane cliffs, west exposure, 1 mile east of Hurricane, alt. 1020 m., Washington Co., 1 May 1932, *Maguire & Blood 1277* (P); stony ground, Anderson's ranch, St. George, 5 Nov. 1922, *Nelson 9990* (M, R); St. George, collection of 1876, *Parry 251* (G, M, US); Buckskin Mts., Kanab, June 1923, *Rodda* (CA); canyon near Copper Mines, Beaverdam Mts., 6 May 1919, *Tidestrom 9357* (US); dry gumbo hillsides, alt. 1800 m., vicinity of Flaming Gorge, Daggett Co., 31 May 1932, *Williams 463* (CA, P).

Nevada: 6 miles east of Reno, 13 May 1929, *Canby 173* (P); flat, Kyle Canyon, Charleston Mts., alt. 2100 m., Clark Co., 10 May 1936, *Clokey 7027, 7028* (CA, F, M, S, US); slopes, Mt. Wheeler, alt. 2300 m., White Pine Co., 20 June 1928, *Cottam 3300* (BYU); pass north of Olcott Peak, Charleston Mts., alt. 1700 m., Lincoln Co., 6 March 1891, *Coville & Funston 387* (US); Trail Canyon, White Mts., alt. 2400 m., 14 June 1930, *Duran 501* (CA, M, P, S, US, UW); on road from Reno to Pyramid Lake, 24 June 1927, *Eastwood 14719* (CA); Pyramid Lake, June 1927, *Eastwood 14742* (CA); on road to Pyramid Lake from Reno, June 1927, *Eastwood 14761* (CA, P); Victory Highway, 5 miles east of Sparks, 8 June 1933, *Eastwood & Howell 29* (CA); Constantia, Washoe Co., 15 April 1927, *Haley* (CA); hillsides, alt. 2200 m., Deer Lodge, Lincoln Co., 6 June 1935, *Hall* (BYU); Pyramid Lake, 28 May 1916, *Headley 13* (US); Goldfield, alt. 2000 m., 4 June 1912, *Heller 10411* (S, US); Reno, 16 May 1899, *Hillman* (P); dry hills, Hunter's Canyon, vicinity of Reno, alt. 1350–1500 m., 18 July 1913, *Hitchcock 513½* (US); Austin, 16 June 1882, *Jones* (P); Rhyolite, alt. 1160 m., 11 April 1907, *Jones* (M, P); Round Mt., Nye Co., Aug. 1915, *Phares* (S); Carson City, alt. 1400 m., 3 July 1931, *Rose* (CA); dry lakes, Verdi, May–June 1889, *Sonne 491* (M); canyon, Montezuma Mt., west of Goldfield, alt. 2100 m., 4 April 1919, *Tidestrom 9771* (M, US); slopes of Sweetwater Mts., near Sweetwater, alt. 2280 m., 1 July 1919, *Tidestrom 10200* (US); Smoky Valley, alt. 1675 m., July 1868, *Watson 1108* in part (G); hillside between Silver City and Dayton, Lyon Co., 27 July 1933, *Wiggins 6755* (S).

California: rocky hills between Rosamund and Mojave, Kern Co., 30 April 1927, *Abrams 11769* (P, S); west side, Walker Pass, alt. 1130 m., Kern Co., 1 May 1927, *Abrams 11920* (P, S); Sespe Creek, near Ten Sycamore Flat, alt. 700–770 m., Ventura Co., 9 June 1908, *Abrams & McGregor 174* (US); near the Frazier Borax Mine, Mt. Pinos, alt. 1600–1900 m., Ventura Co., 12–14 June 1908, *Abrams & McGregor 217* (S); near Mitchell's Canyon, Providence Mts., Mojave Desert, Nov. 1935, *Alpin* (P); granitic soil, arid ridges about 3 miles west of Benton, Mono Co.,

5 Nov. 1931, *Applegate 6904* (S); 3-5 miles east of Topaz, Mono Co., 20 May 1915, *Bolton* (CA); Santa Inez River, March 1861, *Brewer 347* (M); 3½ miles west of Leevining, alt. 2400 m., Mono Co., 23 Aug. 1933, *Clausen 797* (S); hillside, Cayama Valley, alt. 1500 m., Ventura Co., 22 May 1935, *Clokey 6516* (Clo, M); just above Crystal Spring, Coso Mts., alt. 1840 m., Inyo Co., 12 June 1891, *Coville & Funston 923* (US TYPE); Cuddy Canyon, Mt. Pinos region, 19 June 1896, *Dudley & Lamb 4609* (P); Janesville, 15 July 1935, *Epling & Robison* (M); Lone Pine Trail, above Little Cottonwood Creek, alt. 2900 m., Inyo Co., 23 June 1923, *Ferris 3741* (S); northwestern slope of Maturango Peak, Argus Mts., Inyo Co., 12 April 1930, *Ferris 7857* (S); above old town of Panamint, Surprise Canyon, Panamint Mts., alt. 2250 m., Inyo Co., 12 June 1930, *Ferris 7955* (M, S); open sandy desert, Hackstaff, Lassen Co., *Ferris & Duthie 4* (S); quartzite slope, Gold Mt., above Baldwin Lake, alt. 2200 m., San Bernardino Co., 19 June 1932, *Fosberg 8500* (M); between Susanville and Leavitt Lake, Lassen Co., 12 May 1930, *Gillespie 9347* (S); Mt. Pinos, Ventura Co., 16 May 1923, *Hart* (CA); desert slope, from Big Bear region, San Bernardino Co., 4 July 1924, *Hart 81* (CA); granite sand, mouth of a canyon about three miles south of Bishop, alt. 1380 m., Inyo Co., 21 May 1906, *Heller 8299* (CA, M, S); sandy slopes, Frazier Mt. Park, Pinos region, Kern Co., 25 May 1928, *Howell 3824* (CA); rocky slopes, south side of Surprise Canyon near Panamint City, Panamint Mts., Inyo Co., alt. 2400 m., 14 June 1928, *Howell 3924* (CA); rocky slope, Kern Canyon, 7 miles above Kernville, alt. 830 m., Kern Co., 13 May 1930, *Howell 5028* (CA); Rose Mine, San Bernardino Mts., alt. 2120 m., 2 Sept. 1921, *Jaeger 1061* (P, S); sunny mountain side, Prairie Fork of San Gabriel River, San Antonio Mts., alt. 1530 m., 23 Aug. 1917, *Johnston 1721* (P, S); rocky ground at foot of hill, Deadman Point, alt. 900 m., 16 May 1920, *Johnston* (P); Needles, 7 May 1884; *Jones* (P); Cactus Flat in Cushenbury Canyon, 12 May 1926, *Jones* (P, S); Jacumba, San Diego Co., 30 July 1923, *Kendall* (P); eight miles up Mt. Whitney Trail from Lone Pine, overlooking Lone Pine Creek, alt. 2250 m., Inyo Co., 9 June 1935, *Kimber* (S); Hot Springs Peak, alt. 1460-2120 m., Lassen Co., July 1913, *Monnet 839* (CA); dry loose slope, Big Rock Creek, San Gabriel Mts., alt. 1300 m., Los Angeles Co., 27 May 1923, *Munz 6876* (P); dry banks, Seymour Creek, Mt. Pinos, alt. 1900 m., 10 June 1923, *Munz 6979* (P); dry slope, Baldwin Lake, San Bernardino Mts., alt. 2120 m., 2 June 1924, *Munz 8188* (P); base of cliffs, 5 miles south of Bridgeport, Mono Co., 22 June 1928, *Munz 11082* (P); among rocks, Eagle Mts., Colorado Desert, alt. 250 m., 13 April 1921, *Munz & Keck 4951* (P); near Bishop, Inyo Co., 29 June 1937, *Noldke* (CA); Rock Spring, Mohave Desert, 14 May 1876, *Palmer 525* (M, CO-TYPE of *E. nevadensis* var. *pluribracteata*); Rose Mine, San Bernardino Mts., alt. 1800 m., San Bernardino Co., 17 June 1894, *Parish 297* (M, US); summit of Pilot Knob, Mojave Desert, 14 May 1922, *Pierson & Johnston 6510* (P); sandy soil, Argus Mts., April-Sept. 1897, *Purpus 5312* (M, US); rocky canyon sides, west slope of Pleasant Canyon, Panamint Range, alt. 800 m., Inyo Co., 30 March 1937, *Train* (S); 4-5 miles south of Tehachipi, alt. 1525 m., Kern Co., 17 June 1928, *Wolf 2210* (CA, P, S); rocky soil, Leevining Canyon, Sierra Nevada, alt. 2300 m., Mono Co., 5 Nov. 1931, *Wolf 2551* (S).

The dark and persistent leaf-bases and the sessile or short-pedunculate ovulate strobili readily distinguish this species from *E. nevadensis*. Specimens of *E. viridis* from high alti-

tudes and from the northern portions of the range have darker leaf-bases and more numerous branches but are not sufficiently distinct to separate.

12. Ephedra Coryi Reed in Bull. Torr. Bot. Club **63**: 351, *figs. 1, 2.* 1936.

Erect dioecious shrubs, growing from spreading rhizomes, 0.25–1 m. high; branches terete, up to 2.5 mm. thick, opposite or whorled at the nodes, angle of divergence about 22 degrees; internodes 2–4.5 cm. long; young stems almost herbaceous, bright green, slightly asperous, with numerous small longitudinal furrows, becoming yellow; bark of older stems red-brown, cracked and fissured irregularly; terminal buds 1–3 mm. long, obtusely conical; leaves opposite, acutely tipped from a dorso-median thickening, connate for one-third to three-fourths their length; sheath membranaceous-margined, soon falling to leave the brown, thickened and persistent base; staminate spikes paired or numerous at the nodes of the young branches, obovate, 4–7 mm. long, sessile or short-pedunculate, bracts opposite, slightly connate at the base, in 5–9 whorls, ovate, 2–4 mm. long, 2–3 mm. broad, membranaceous, light yellow, the lower whorl empty; perianth slightly exceeding the subtending bracts; staminal column 2–4 mm. long, one-fourth exserted, with 5–7 sessile or short-stipitate anthers; ovulate spikes opposite or several at the nodes of the young branches, obovate to spherical, 7–15 mm. long, peduncle 3–20 mm. long, with two pairs of bracts, one basal, the other subterminal, bracts opposite, in 3–4 whorls, ovate-acute at first, becoming yellow, fleshy and orbicular at maturity; seeds paired, trigonal, brown to chestnut, smooth, 5–7 mm. long, usually equaling or slightly exceeding the bracts; tubillus straight, slightly exserted, the barely contorted ligulate limb recurved.

Distribution: west-central Texas.

SPECIMENS EXAMINED:

TEXAS: 11¼ miles east of Seminole, Gaines Co., 20 May 1935, *Cory 13711* (US); Boll's ranch, 10 miles southeast of Lubbock, 6 April 1930, *Demaree 7475* (G, M, S); dry prairies near Stanton, Martin Co., 13 June 1900, *Eggert* (M); sandy soil, open ground, Big Spring, Howard Co., 9 July 1917, *Palmer 12491* (CA, M, US); 11¼

miles east of Seminole, Gaines Co., 20 May 1935, *Parks & Cory 11707* (T); Brownfield, *Reed* (US TYPE, not seen); Brownfield, 8 April 1935, *Reed* (TTC); sandy soil, about 12 miles southwest of Lamesa, 22 April 1935, *Reed* (TTC); loose and sandy soil, 1 mile west of Shacktown, 14 June 1934, *Reed 3718* (TTC); sandy, semi-arid soils, level ground, Cedar Lake, about 20 miles southwest of Lamesa, 14 June 1934, *Reed 3719* (TTC); loose and sandy soil, west of Ackerby, 15 June 1934, *Reed 3735* (TTC, US); sandy soil, railroad right-of-way, Meadow, 5 March 1934, *Reed 3897* (TTC); loose sandy soil, between O'Donnell and Lamesa, 16 Sept. 1934, *Reed 4103* (TTC); Meadow, 4 July 1935, *Reed 4200* (TTC); between Wellman and Meadow, 29 July 1934, *Reed 4354* (TTC).

12a. E. Coryi var. **viscida** Cutler,[29] n. var.

Differs from the species in having the aerial stems frequently branching, the young stems viscid, and the bracts not fleshy.

Distribution: southwestern Colorado, northwestern New Mexico, and adjacent Utah and Arizona.

SPECIMENS EXAMINED:

COLORADO: Deer Run, Gunnison watershed, alt. 1430 m., coll. of 1901, *Baker 921* (P); plains south of Mancos, 8 July 1898, *Baker, Earle & Tracy 397* (M, P); San Juan Valley, July 1875, *Brandegee 7754* (M); dry situations, Church Rock Canyon, 17 June 1927, *Cottam 2319* (BYU); Gunnison Mesa, Grand Junction, 15 May 1916, *Eastwood 5121* (CA); Book Cliff road, Grand Junction, 18 May 1916, *Eastwood 5190, 5191* (CA, S); clay, Grand Junction, alt. 1360 m., 21 June 1894, *Jones 5476v* (P); foothills and mountains, Mesa Co., summer of 1893, *Long* (G); Spruce Canyon, near camp ground, Mesa Verde National Park, 8 July 1929, *Mathias 645* (M, P); dry hills, alt. 1650 m., 28 May 1914, *Payson 367* (M, S); Glenwood Springs, 1 Sept. 1917, *Payson 1199* (M); talus slope of sand and shale, Colorado National Monument, 10 miles southwest of Fruita, alt. 1830 m., 13 Aug. 1937, *Rollins 1931* (CA, M); dry, rocky foothills, Paradox, alt. 1610 m., Montrose Co., 22 June 1912, *Walker 161* (M); dry canyon slope, Norwood Hill, alt. 2200 m., San Miguel Co., 20 Aug. 1912, *Walker 511* (M, P).

NEW MEXICO: Frijoles Canyon, alt. 2000 m., vicinity of Santa Fe, 4 June 1936, *Arsène 22799* (US); along Cuba road, near Bloomfield, San Juan Co., 4 July 1929, *Mathias 611, 612* (M, P); dry hills, alt. 1550–1650 m., vicinity of Farmington, San Juan Co., 17 July 1911, *Standley 6938* (US); mountain side, Bandelier National Monument, 24 June 1935, *Studhalter, Cox & Langford 52449* (US).

ARIZONA: desert near Tuba, 15–31 July 1920, *Clute 100* (M); Montezuma Castle National Monument, Yavapai Co., 20 May 1937, *Cutler 1115* (M, UW); sandy desert, 15 miles east of Tuba City, Coconino Co., 21 May 1937, *Cutler 1147* (M, UW); Monument Canyon, 7 miles southeast of Chinle, Apache Co., 12 June 1938, *Cutler 2143–2148* (M); Canyon de Chelly, near Chinle, Apache Co., 13 June 1938, *Cutler 2156* (M); loose sand, 4 miles south of Round Rock, Apache Co., 14 June

[29] **E. Coryi** var. **viscida** Cutler, var. nov., a specie differt caulibus ligneis aeriis saepe ramosis, juventate viscidis, bracteis non valde carnosis et non saepe esculentis.

1938, *Cutler 2161–2165, 2169, 2170* (M); sands of mesa, 5 miles west of Rock Point, Apache Co., 15 June 1938, *Cutler 2174, 2183, 2200* (M); loose sand, 10 miles west of Rock Point, 15 June 1938, *Cutler 2209* (M TYPE), *2210* (M); loose sand, 5 miles south of Dennehotso, Apache Co., 15 June 1938, *Cutler 2214, 2216, 2218, 2219* (M); between Tuba City and Tonalea, Coconino Co., 10 Sept. 1938, *Eastwood & Howell* (CA); between Kayenta and Monument Valley, Navajo Co., 14 Sept. 1938, *Eastwood & Howell* (CA); near Canyon Diablo, Coconino Co., 18 May 1931, *McKelvey 2284* (P); steep, rocky, brushy slopes near Indian Gardens, Oak Creek Canyon, 23 May 1935, *Nelson & Nelson 2087* (M); near Ganado, 17 May 1934, *Peebles 9352* (US); sandstone bluff, edge of marsh, alt. 1520 m., near Tuba City, Navajo Co., 2 June 1935, *Peebles & Fulton 11857* (US); 14 miles north of Kayenta, alt. 1600 m., Navajo Co., 4 June 1935, *Peebles & Fulton 11935* (US); gorge of the Little Colorado River, alt. 1650 m., Coconino Co., 8 June 1937, *Peebles & Smith 13340* (US); in sand, 5 miles southeast of Tuba City, alt. 1550 m., Coconino Co., 8 June 1937, *Peebles & Smith 13361* (US); Oraibi, alt. 2000 m., 29 June 1935, *Whiting 756/732* (UNM); Navajo Springs, 24 July 1892, *Wooton* (NNAM).

UTAH: cliffs, Moab, 7 June 1927, *Cottam 2138* (BYU); sandy bluff, alt. 1800 m., Blanding, San Juan Co., 1 July 1927, *Cottam 2502, 2518* (BYU); dry flat, Monument Valley, alt. 1680 m., 2 July 1927, *Cottam 2566* (BYU); hills above Comb Wash, 8 miles west of Bluff, San Juan Co., 21 June 1936, *Cutler 2328* (M); loose sand, 4 miles north of Bluff, San Juan Co., 21 June 1938, *Cutler 2340, 2341* (M); 6 miles northwest of La Sal Junction, San Juan Co., 23 June 1938, *Cutler 2365* (M); under an overhanging cliff of Augusta Natural Bridge, San Juan Co., 7 May 1933, *Harrison 5913* (M); canyon bottom, Augusta Natural Bridge, San Juan Co., 7 May 1933, *Harrison 5914* (M); Moab, 30 Aug. 1891, *Jones* (P); 1½ miles east of Armstrong Canyon, National Bridges Monument, alt. 1750 m., San Juan Co., 22 June 1932, *Maguire & Redd 1631* (M); western slope of La Sal Mts., near Little Springs, alt. 2000–2200 m., 5–6 July 1911, *Rydberg & Garrett 8571* (US).

This variety is dominant over extensive stretches of sandy desert in the Navajo Indian Reservation and near-by regions and forms large hummocks. In the north and at high altitudes it is difficult to distinguish vegetative material from *E. viridis*, but the long peduncle of the ovulate strobili and the usual viscid stems distinguish other specimens. A probable hybrid of this variety and *E. Torreyana* has been given the binomial *Ephedra arenicola* earlier in this paper.

13. Ephedra antisyphilitica Berland. ex C. A. Mey. in Mém. Acad. Imp. Sci. St. Petersburg, VI, Sci. Nat. **5**: 291. 1846.

E. occidentalis Torr. ex Parl. in DC., Prodr. **16**^{2}: 354. 1868.

E. texana Reed in Bull. Torr. Bot. Club **62**: 43. 1935.

Erect or spreading dioecious shrub, 0.25–1 m. high; branches stiff, hard, terete, up to 4 mm. thick, alternate or whorled at the nodes, angle of divergence about 48 degrees; internodes 2–5

cm. long; young stems green, glaucous, almost smooth, with many small longitudinal furrows, becoming yellow-green, then gray-green; bark of older stems cinereous, slightly cracked and fissured; terminal buds 2–3 mm. long, obtusely pointed; leaves binate, 1–3 mm. long, obtusely tipped from a dorso-median herbaceous thickening, connate for two-thirds to nine-tenths their total length; sheath membranaceous, later splitting and falling; staminate spikes solitary or paired at the nodes of the young branches, lanceolate-elliptic, 5–8 mm. long, almost sessile, 5–8 pairs of bracts, obovate, one-eighth connate at the base, 2–3.5 mm. long, 2–3 mm. broad, slightly thickened, margins membranaceous, pale green to reddish, the lower pair empty; perianth slightly exceeding the subtending bract; staminal column 4–5 mm. long, one-half exserted, with 4–6 sessile or very short-stipitate anthers; ovulate spikes solitary or paired at the nodes of the young branches, rarely several at a node, elliptic, 6–11 mm. long, nearly sessile, 4–6 pairs of bracts, ovate, one-eighth to seven-eighths connate, the inner pairs becoming fleshy, red, succulent when ripe; seed solitary, trigonal or occasionally tetragonal, light brown to chestnut, smooth, 6–9 mm. long, 2–3.5 mm. broad, conspicuously exserted; tubillus straight, slightly exserted, ligulate limb slightly contorted.

Distribution: southwestern Oklahoma, and west-central Texas to northeastern Mexico.

SPECIMENS EXAMINED:

OKLAHOMA: along the Red River, Harman Co., 16 Dec. 1933, *Goodman & Barkley* (F, G, M).

TEXAS: desert plains, Nolan Co., 3 Aug. 1934, *Barkley* (M); Rio Frio, "entre Laredo et Dejar," Feb. 1828, *Berlandier 1590* [=*320*] (C, M, CO-TYPES); Big Springs, 20–23 May 1899, *Bray 394* (US); San Antonio, Bexar Co., 15 April 1911, *Clemens & Clemens 380* (CA, M, P); 9 miles northwest of Edinburg, Hidalgo Co., 30 Dec. 1933, *Clover 1593* (CA); 3 miles east of San Angelo, Tom Green Co., 28 April 1931, *Cory* (M); 15 miles north of Eldorado, Schleicher Co., 29 April 1931, *Cory* (US); Croton Camp, Matador Ranch, Dickens Co., 15 June 1904, *Coville 1871* (US); Texas Agricultural Experiment Station number 14, west of Rock Springs, Edwards Co., 24 May 1938, *Cutler 1815, 1816* (M); pasture 12 miles south of Sonora, Sutton Co., 24 May 1938, *Cutler 1817* (M); ungrazed field, 10 miles south of Sonora, Sutton Co., 24 May 1938, *Cutler 1819, 1820* (M); 12 miles southwest of Sonora, Sutton Co., 24 May 1938, *Cutler 1822* (M); 14 miles south of Juno, Val Verde Co., 24 May 1938, *Cutler 1830* (M); pastures, 7 miles west of Comstock,

Val Verde Co., 24 May 1938, *Cutler 1831* (M); along railroad 4 miles w. of Shumla, Val Verde Co., 24 May 1938, *Cutler 1833* (M); pasture ½ mile west of Dryden, Terrell Co., 24 May 1938, *Cutler 1837–1839* (M); gravel plain 1 mile west of Sanderson, Terrell Co., 26 May 1938, *Cutler 1840–1842* (M); along railroad 8 miles west of Sanderson, Terrell Co., 26 May 1938, *Cutler 1845* (M); rocky hills near Stanton, Martin Co., 13 June 1900, *Eggert* (M); hills and valleys, Laredo, 18 Feb. 1919, *Hanson 344* (G, M, UW); Nibo Mt., Gillespie Co., *Jermy 154* (M, US); Experiment Station, Sonora, 21 April 1931, *Jones 28371* (CA, M, P, S); Laredo, 24 March 1932, *Jones 29009* (M); below Laredo, 26 March 1932, *Jones* (P); between Uvalde and Del Rio, 18 April 1931, *McKelvey 1895* (P); between the Frio and the Nueces rivers, on the road to Laredo, 27–28 Jan. 1880, *Palmer 1289, 1292* (M); dry limestone hills, Concan, Uvalde Co., 14 June 1916, *Palmer 10190* (US, S); dry limestone hills, San Angelo, Tom Green Co., 28 June 1916, *Palmer 10309* (M, S, US); dry calcareous hillsides, Telegraph, Kimble Co., 8 Oct. 1916, *Palmer 10951* (M, US); sandstone hills, Campbelton, Atascosa Co., 9 March 1917, *Palmer 11238* (CA, M, UC, US); dry rocky hills, Brownwood, Brown Co., 18 Oct. 1917, *Palmer 13028* (CA, M, US); dry limestone ledges near Brownwood, Brown Co., 31 Oct. 1924, *Palmer 26783* (M); along caprock escarpment and the broken country to the eastward, Buffalo Springs, Lubbock, 15 April 1934, *Reed 3628* (US); caliche soil along escarpment, Buffalo Springs, Lubbock, *Reed 3946* (R); Buffalo Springs, Lubbock, 30 Sept. 1934, *Reed 4113* (R); Johnson's ranch, Yellow House Canyon, Lubbock, 2 March 1935, *Reed 4143* (R); Rocky Bluffs, Brown Co., April 1882, *Reverchon 925* (F, M, US); vicinity of Langtry, 27 March 1908, *Rose 11621* (US); pasture, La Salle Co., 4 May 1919, *Schulz 90* (US); near Paint Rock, Concho Co., 27 April 1931, *Terry V21* (P); near Eagle Pass, Maverick Co., 6 Aug. 1925, *Tharp 3334* (US); San Antonio, *Wilkinson 113* (M).

MEXICO:

SAN LUIS POTOSI: region of San Luis Potosi, 1878, *Parry & Palmer 854* (M).

NUEVO LEON: mountains near Icamole, 3 Feb. 1907, *Safford 1251* (M).

Ephedra antisyphilitica and *E. pedunculata* have been regarded frequently as a single species, yet they are very distinct and no true intergrading forms have been found. The former species rarely has a pair of seeds but never assumes the clambering habit or attains the long stipitation of the anthers that characterizes *E. pedunculata*. The latter appears frequently to have a habit of erect growth when it has been repeatedly grazed over by stock.

13a. E. antisyphilitica var. **brachycarpa** Cory in Rhodora 40: 218. 1938.

Like the species except the ovulate spikes are shorter, less than 6 mm. long, and broader; seed broader, about 3 mm. wide, definitely trigonous, included.

Distribution: known only from Kent and Bexar counties, Texas.

SPECIMENS EXAMINED:

TEXAS: eastern Bexar Co., 25 March 1935, *Parks 12175* (US TYPE, not seen); eastern Bexar Co., 25 March 1935, *Parks, 12176, 12177* (T).

14. **Ephedra compacta** Rose in Contrib. U. S. Nat. Herb. **12**: 261. 1909.

Erect or spreading, compact dioecious shrub, 0.3–0.5 m. high; branches stiff, hard, almost terete, up to 2.5 mm. thick, opposite or whorled at the nodes, angle of divergence about 37°; internodes 0.5–3 cm. long; young stems gray-green, glaucous, with several longitudinal furrows, becoming distinctly gray; bark of older stems gray-brown, lightly fissured and cracked; terminal buds about 1.5 mm. long, conical; leaves opposite, 1.5–3 mm. long, obtusely pointed, connate for one-half to seven-eighths their length; sheath chartaceous, red-brown in earlier stages, later gray and divided, subpersistent; staminate spikes not seen; ovulate spikes solitary or paired at the nodes of the young branches, ovate, 4–8 mm. long, almost sessile, 3–5 pairs bracts, broadly ovate, 4–5 mm. long, 3–5 mm. broad, one-eighth to three-fourths connate when mature, the inner pairs red and succulent; seeds paired, light brown to chestnut, almost smooth, 3.5–5.5 mm. long, 2–3 mm. broad, slightly exceeding the bracts; tubillus straight, barely exserted, the tip truncate.

Distribution: east-central Mexico, Coahuila to Oaxaca.

SPECIMENS EXAMINED:

MEXICO:

OAXACA: Las Naranjas, Aug. 1908, *Purpus 3054* (F, M, US).

PUEBLA: Esperanza, Sept. 1911, *Purpus 5698* (F, M, US); near Tehuacan, 1–2 Aug. 1901, *Rose & Hay 5835* (US); near El Riego, Tehuacan, 2 Sept. 1905, *Rose & Hay 10023* (US); hills west of town, near Tehuacan, 2 Sept. 1906, *Rose & Rose 11274* (US TYPE); near Tehuacan, 30 Aug.–8 Sept. 1905, *Rose, Painter & Rose 10023* (US).

SAN LUIS POTOSI: Charcas, July–Aug. 1934, *Lundell 5165* (CA, F, US).

COAHUILA: rocky soil, battlefield near Buena Vista, 19 May 1848, *Gregg 53* in part (G, M).

15. **Ephedra pedunculata** Engelm. ex Wats. in Proc. Am. Acad. **18**: 157. 1883.

Vine-like shrub, trailing on ground or clambering over bushes and trees, often to a height of 6–7 m., dioecious; branches lax, firm, terete, up to 3 mm. thick, alternate, or rarely, whorled at the nodes, angle of divergence about 52 degrees, internodes 1–7 cm. long; young stems gray-green, glaucous, almost smooth, with several moderately deep longitudinal furrows, becoming more green, then yellow-green; bark of older stems cinereous, slightly cracked and fissured; terminal buds 1–3 mm. long, attenuated; leaves binate, 1–3 mm. long, obtusely tipped from a dorso-median herbaceous thickening, connate from two-thirds to nine-tenths their total length; sheath membranaceous, later splitting; staminate spikes solitary or paired at the nodes of the young branches, lanceolate-elliptic, 4–8 mm. long, peduncles 0–12 mm. long, 6–12 pairs of bracts, obovate, free or one-eighth connate at the base, 1.5–3.5 mm. long, 1.5–3 mm. broad, slightly thickened, margins membranaceous, pale yellow to reddish, the lower pair empty; perianth slightly exceeding the subtending bract; staminal column 3–5 mm. long, one-half exserted, with 4–6 definitely stipitate anthers; ovulate spikes solitary or paired at the nodes of the young branches, rarely several at a node, elliptic, 6–10 mm. long, peduncles 1–20 mm. long, 3–6 pairs of bracts, ovate, one-eighth to seven-eighths connate, the inner pairs becoming fleshy, red, succulent when ripe; seeds paired, trigonal, light-brown to chestnut, smooth, 4–9 mm. long, 2–3.5 mm. broad, conspicuously exserted; tubillus slightly kinked, somewhat exserted, limb contorted.

Distribution: southwestern Texas east of the Pecos River, to San Luis Potosi, Mexico.

SPECIMENS EXAMINED:

TEXAS: between Barrocetes ranch and Aquilares, Zapata Co., 19 Dec. 1933, *Clover 1584* (CA); Ranch Experiment Station, Edwards Co., 9 Sept. 1931, *Cory* (M); climbing on fence and on spiny shrubs, 12 miles south-southwest of Sonora, Sutton Co., 24 May 1938, *Cutler 1821* (M); climbing over trees and shrubs, 14 miles south of Juno, Val Verde Co., 24 May 1938, *Cutler 1827* (M); 1890, *Nealley 258* (F, R); Uvalde, 90 miles northwest of San Antonio, 1880, *Palmer 1291* (M TYPE, US); Rio Frio, Oct. 1851, *Parry* (M); Barrens, Brown Co., April 1882, *Reverchon* (F); Uvalde Co., June 1846, *Reverchon 1658* (M).

MEXICO:

TAMAULIPAS: La Sardiña, Sierra de San Carlos, alt. 650 m., 14 Aug. 1930, *Bartlett 1095* (US).

SAN LUIS POTOSI: en route from San Luis Potosi to Tampico, Dec. 1878–Feb. 1879, *Palmer* (I); San Luis Potosi and vicinity, July–Aug. 1898, *Palmer 702* (US); San Luis Potosi, 1878, *Parry & Palmer 855* (F, I, M, US); San Luis Potosi, Aug. 1879, *Schaffner 279* (CA, F, P, US).

NUEVO LEON: Lampazos, 26 June, *Edwards* (F).

COAHUILA: States of Coahuila and Nuevo Leon, July 1880, *Palmer 1289* (I, M, US); Juarez, 100 miles north of Monclova, Sept. 1880, *Palmer 1290* (I, M, US); Saltillo, 1898, *Palmer 283* (F, M, US).

ZACATECAS: plains, Cedros, June 1908, *Lloyd 75, 214* (M, US); near Concepcion del Oro, 22 Nov. 1902, *Palmer 372* (US).

CHIHUAHUA: Bachimba Canyon, 15 April 1885, *Pringle 134* (F, US); Sta. Eulalia plains, 13 April 1885, *Wilkinson 117* (US) in part.

DURANGO: dry valley between Mapimi and Guajuguilla, 18 April 1867, *Gregg 484* (M); Durango, April–Nov. 1896, *Palmer 149* (F, M, US).

LIST OF EXSICCATAE

The distribution numbers are in *italics*. Unnumbered collections are indicated by a dash. The numbers in parentheses are the species numbers used in this monograph.

Abrams, Le Roy. *3204, 3489, 3600, 3676* in part (6); *3676* in part (10); *11769, 11920* (11).
Abrams, L. R., & E. A. McGregor. *499* (7); *174, 217* (11).
Allen, Eva. *177* (1).
Anthony, A. W. *281* (7).
Aplin, J. A. — (11).
Applegate, E. I. *6904* (11).
Arsène, Bro. G. *19034* (3); *22799* (12a).
Atsalt, S. (6).
Bacigalupi, Rimo, see—R. S. Ferris.
Bailey, Harold, & W. Robison. — (10).
Baker, Carl F. *921* in part (6); *921* in part (12a).
Baker, C. F., F. S. Earle, & S. M. Tracy. *397* (12a).
Ballon, L. — (6).
Ballou, F. O. — (1).
Barkley, Fred A. *3232* (3); *3115, 3333* (11); — (13); see—G. J. Goodman.
Barlow, Bronson. — (1).
Bartlett, Harley Harris. *1095* (15).
Bartram, Edwin B. *16* (1).
Becraft, R. J., see—B. Maguire.
Benke, *5022* (3).
Benson, Lyman. *3358* (6); *3446* (10).
Berlandier, J. L. [*320*] *1590* (13).
Bigelow, J. M. *3* (1); *4* (3); *2* (7).
Blood, H. L., see—B. Maguire.
Bolton, A. L. — (11).
Braem, Selma. — (6); — (9).
Bray, William. *394* (13).
Brandegee, T. S. — (7); *7754* (12a).
Brewer, William H. *347* (11).
Burrall, H. D. — (11).
Campbell, Mrs. R. W. — (1).
Canby, W. *173* (11).
Carlson, John I. — (1).
Chandler, H. P. *5165* (6).
Clausen, J. *797* (11).
Clemens, Mr. & Mrs. Joseph. *380* (13).
Clemens, Mrs. Joseph. — (7).
Cleveland, D. — (6).
Clokey, Ira W. *7816* (3); *8225* (5); *6510-6514* (9); *7465* (10); *6516, 7127, 7027, 7028* (11).
Clokey, I. W., & Bonnie C. Templeton. *5675, 5676* (5); *5784* (6).

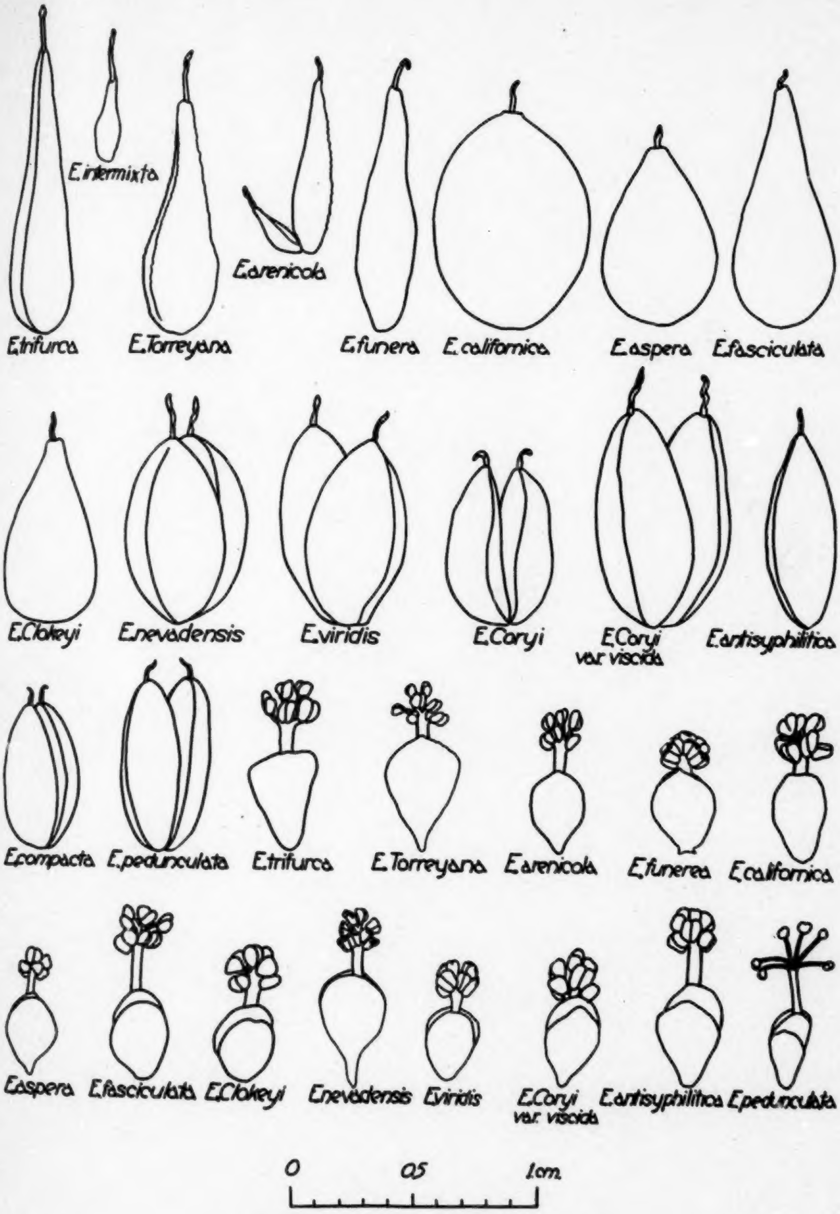
Index to Scientific Names

Accepted names are in Roman type; synonyms, in *italics;* the principal reference and new names in **bold face** type.

Explanation of Plate

PLATE 27

Typical seeds with tubilli; typical staminate bracts with included perianths and antherophores.



CUTLER—MONOGRAPH OF EPHEDRA

Explanation of Plate

PLATE 28

Geographical distribution of species of *Ephedra*.

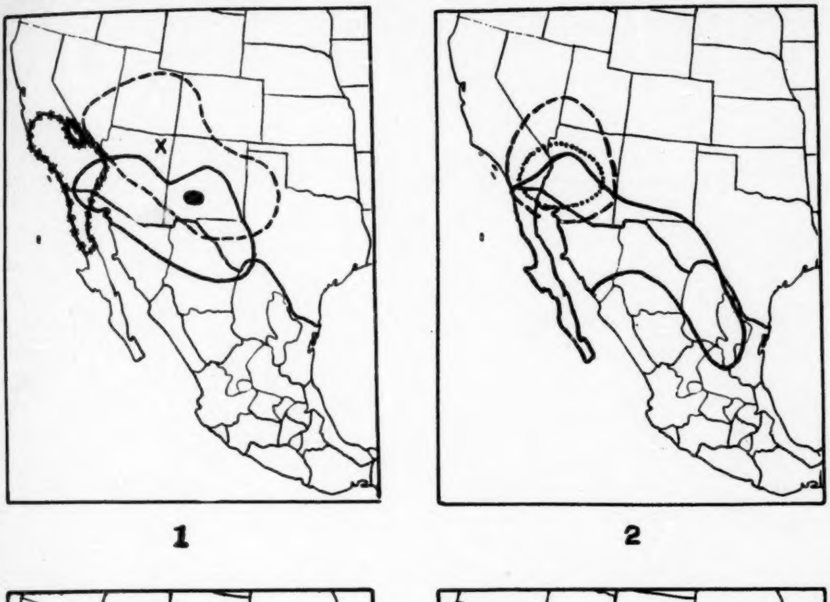
Fig. 1. *E. trifurca* ————————
E. intermixta ●
E. Torreyana — — — — — —
E. arenicola ×
E. funerea ————————*
E. californica —||—||—||—

Fig. 2. *E. aspera* ————————
E. fasciculata ....
E. Clokeyi — — — — — —

Fig. 3. *E. nevadensis* — — — — — —*
E. viridis ————————
E. Coryi —×—×—×—
E. Coryi var. *viscida* —||—||—||—

Fig. 4. *E. antisyphilitica* ————————
E. compacta —||—||—||—
E. pedunculata — — — — — —

* Note: Since the maps were made *E. funerea* has been collected in southeastern Nevada (Clark Co.), and *E. nevadensis*, in Harney Co., Oregon.



CUTLER—MONOGRAPH OF EPHEDRA

GENERAL INDEX TO VOLUME XXVI

New scientific names of plants and the final members of new combinations are printed in **bold face type**; synonyms and page numbers having reference to figures and plates, in *italics;* and previously published names and all other matter, in ordinary type.
